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FINAL REPORT FOR

**"SPACE RESEARCH, EDUCATION, AND RELATED ACTIVITIES  
IN THE SPACE SCIENCES"**

Cooperative Agreement #NCC 5 - 356

For the period October 1, 2001 – March 31, 2002

Submitted To:

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From:

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Dr. David Black, PI

A handwritten signature in black ink, which appears to read "David N. Holdridge". The signature is written over a horizontal line and has a long, sweeping tail that extends to the right.

Mr. David Holdridge  
Program Manager

07/19/02

## **INTRODUCTION:**

The Universities Space Research Association received an award of Cooperative Agreement #NCC 5 - 356 on September 29, 1998. The mission of this activity, known as the Cooperative Program in Space Sciences (CPSS), is to conduct space science research and leading-edge instrumentation and technology development, enable research by the space sciences communities, and to expedite the effective dissemination of space science research, technology, data, and information to the educational community and the general public.

To fulfill this mission, USRA recruits and maintains a staff of scientific researchers, operates a series of guest investigator facilities, organizes scientific meetings and workshops, and encourages various interactions with students and university faculty members.

This is the final report from this now completed Cooperative Agreement.

## **FINANCIAL & OPERATIONS SUMMARY:**

The original award amount totaled \$19,291,403.00. This was revised downward to \$ 18,241,413.03 in March, 2002. The actual costs, as of July 15, 2002, were \$ 18,247,256.07. At the end of the cooperative agreement, USRA had 35 Total Direct Staff Members under employment. There were 33 Active Staff Scientists (one on TDY to INTEGRAL Data Center in Geneva, Switzerland. There was 1 On-Site Administrator (CGRO/GLAST), and one Graduate Student. Thirty of these employees worked in Code 660, 4 in Code 690, and one in Code 680. The staff turnover has been running at a level of 20% over the last 10 years experience in the GSFC Space Sciences Directorate. Over the last year, there were seven new hires and five departures. These individuals arrive from and return to a mixture of Government, university, industry, and foreign organizations. The vast majority of new hires are a result of national recruitments. Last year we conducted 6 different recruitment exercises.

92 short-term visitors and 20 consultants were brought in to support the mission of the Space Sciences Directorate through USRA during the past year. USRA scientists led 10 teacher and k-12 student space science education workshops over the last year. We conducted a successful recruitment exercise to interest and attract summer students to the GSFC Space Sciences Directorate. Over 50 students applied and seven were placed. USRA scientists and administrative personnel combined to run and support 15 scientific meetings and/or workshops between April 2001 and March 2002.

## **ACCOMPLISHMENTS:**

### **Scientific Research and Instrument Development:**

As an indication of scientific research accomplishments, USRA scientists working under this Cooperative Agreement submitted 85 PI-level research and education proposals during the year. Indicative of the high level of community action, a majority (81) of these submitted proposals were made in conjunction with a university-based collaborator. There were seventeen (thus far) awarded – eleven with observing time only, and six grants totaling \$835,493.00 (65 proposals are currently in the selection process). Approximately 110 papers were published; 82% in refereed journals, averaging 3.3 published papers per Ph.D. staff member (papers with multiple USRA co-authors were counted as one). A publication list is attached to this report.

What follows are excerpts from individual annual reports of the USRA scientific staff.

## LABORATORY FOR HIGH ENERGY ASTROPHYSICS (660)

### ACTIVITY 660-02: Detector Technology Development

#### DR. JOHN KRIZMANIC:

1. OWL: Continue the development of an independent Monte Carlo simulation of the generation of airshowers, atmospheric fluorescence generation of light, atmospheric attenuation, and model of the OWL instrument. The Monte Carlo is sufficiently developed to be used as a design tool to understand instrument performance and perform design trade studies on various instrument designs.  
  
As an example, the results of the simulation were a vital component in developing the OWL instrument during the recent ISAL and IMDC studies. The simulation has been used to perform studies of the sensitivity of the OWL instrument to observe neutrino-induced interactions and their subsequent airshowers in the atmosphere. Overall, this simulation effort and results have been instrumental in demonstrating the physics potential of OWL. The OWL research also involves collaborating with GSFC engineers, especially optical and mechanical, to develop realistic instrument designs.
2. Fresnel Lens Gamma Ray Mission: I have been working with physicists (N. Gehrels; NASA/GSFC and Gerry Skinner; CESR, Toulouse, France) to develop the Fresnel Gamma Ray Mission. In January, 2002 we performed a weeklong IMDC run on a full mission profile followed by a few day mini-IMDC run on a pathfinder mission. Due to time constraints of my other collaborators, I was effectively the mission scientist for the IMDC meetings. The IMDC runs were very successful and determined spacecraft designs and a mission profile that is technically feasible. The Fresnel Gamma Ray Mission is supported through NASA's Revolutionary Aerospace System Concepts (RASC) funding. I have been responsible for writing the RASC status reports. The Fresnel Lens research and development is supported by internal GSFC IR&D, and I have been writing these status reports. I am also involved in working with mechanical and fabrication engineers at GSFC to develop Fresnel lens designs, fabrication techniques, and eventually actual lenses for both the main mission and ground testing at the NASA MSFC X-ray Calibration Facility (MXCF).
3. High energy neutrino astrophysics: I have developed an initial upward-moving airshower simulation that included 3-dimensional effects of angular dispersion inherent to the airshower and the effects of a spherical Earth to determine the Cherenkov light signal profile at sub-orbital and orbital altitudes. These results led to the submission of a NASA SRT proposal, with myself as the PI, to develop in detail a flavor-dependent neutrino airshower simulation to be used to study the ability of a orbital and sub-orbital instruments to measure astrophysical neutrino-induced upward airshowers
4. GLAST: Develop systematic procedures for testing scintillator tiles and perform tile response measurements. The base design for the GLAST ACD tiles uses fiber optics imbedded in the tiles and coupled to photo-multiplier tubes to record the signal generated by traversing charged particles. The response of a tile as a function of radiation position was performed using a collimated, b radiation source. The results demonstrated a degradation of the tile response near the edges, and this effect was verified via muon measurements performed by Alex Moiseev. These results were crucial in understanding the effect and formed the basis for an improved design that should minimize this edge effect.
5. Detector Research and Development: Served as a consultant in-house at LHEA for researchers to aid in the development of novel particle detectors and related electronics. In particular, served as an informal on-call scientist to aid in troubleshooting the SWIFT CZT detector element characterization software and hardware.

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## **ACTIVITY 660-03: Cosmic Ray Telescopes**

### **DR. ALEXANDER MOISEEV:**

1. Currently the Anti-Coincidence Detector (ACD) team is ready for Preliminary Design Review (PDR), and even almost ready for the following Critical Design Review (CDR). We have successfully (now) passed through a number of things related to the bringing the design to the required shape, including a number of different level reviews.
  - a) The principal ACD design is carefully optimized and proven by the detailed simulations and beam tests. The results are given in a number of notes.
  - b) The design of scintillating tiles is optimized basing on the numerous tests (both beam and bench). More than 40 tile prototypes were fabricated and tested to choose the best design. The balloon ACD was built and successfully flown by high altitude balloon as a component of BFEM (balloon GLAST prototype) last summer.
  - c) The requirements for the fabrication of scintillating tiles, scintillating fiber ribbons, photo-multipliers and ASIC have been defined and written. The production of flight prototypes has started (tiles, ribbons, PMTs), currently we are checking their compliance with our requirements to give OK for further production
  - d) The number of tests should be performed on ACD in different steps of its fabrication. It starts from the design qualification tests, the acceptance tests of separate items, further numerous tests during ACD integration, ACD pre-ship test, different level tests while ACD is integrated in GLAST (aliveness, limited functional, full functional, etc.). We defined the principal schemes and approaches for all these tests, and currently preparing the documentation for the test procedures. Also we currently are in a process of the design qualification tests (PMT qualification, tile qualification, ribbon qualification, tile thermal cycling).
  - e) The principal ACD design has been proven to meet the requirements (level III requirements for the ACD). The task is to assure that during the detailed designing there will be no design solutions, which would degrade the instrument performance. This is almost every day work.
2. The main output of my activity in BESS is published papers and presentations where I contribute at the level of the results discussion and interpretation. My contribution to BESS will grow soon because Goddard became responsible in providing time-of-flight detectors for the BESS flight in Antarctica.

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## **ACTIVITIES 661-01 & 661-02: Gamma Ray Large Area Space Telescope (GLAST) and Compton Gamma Ray Observatory (CGRO)**

### **DR. JERRY BONNELL:**

1. GLAST Project PR movie was completed. I made major contributions to the script, and visual content and participated in the post-production editing.
  - a) I was a member of the GLAST Data Products working group whose report was completed and submitted to the Project Scientist. This was a major effort over many months in which committee members proposed and documented a set of definitions for GLAST science data products and their production.
  - b) Contributions to NOVA PBS episode "Death Star" detailing the discovery of the cosmological nature of Gamma Ray Bursts and BATSE/ GRO role.
  - c) Established a comparison of long-lag BATSE gamma-ray bursts with CfA supernova catalog (publication of results is in preparation).

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## **ACTIVITIES 661-02 & 661-03:**

### **CGRO & International Gamma Ray Astrophysics Laboratory (INTEGRAL)**

#### **DR. CHRIS SHRADER:**

1. ISDAG: Maintenance and testing of delivered software was conducted during the reporting period. This includes the "SPIHIST" utility, which produces INTEGRAL/SPI binned detector count spectra. Several other related packages are nearing completion. I also participated in the acquisition and analysis of the laboratory calibration data for the spectrometer. Another major activity, for which I have maintained a leading role, is the development of INTEGRAL-specific capabilities to be incorporated in the XSPEC version 12 release scheduled for late 2002. In each case, I worked closely with members of our team; 1 USRA scientists and 1 EITL programmer. A presentation describing INTEGRAL spectral data analysis was made at the Gamma 2001 symposium.
2. CGRO SSC: I played in central role in a NASA convened review of the CGRO final data archive and software repository. Plans were formulated with the CGRO instrument teams to complete the archiving of standard data products. A number of deficiencies and problems with existing data were identified and plans to address them were formulated. Since then, I have coordinated deliveries (or re-deliveries) of a large volume (10 CD ROMs) of CGRO data products, notable from the BATSE and OSSE instrument teams. In addition, I have developed a plan for final migration of key elements of the CGRO instrument specific software into the FTOOLS repository. Substantial progress has been made; two scientific programmers have been hired and placed under my supervision. Five new FTOOLS modules have been delivered, and bug fixes or improvements have been implemented for 3 other FTOOLS.
3. GOF: In coordinated with the NASA INTEGRAL Program Scientists at NASA HQ, I issued a solicitation for INTEGRAL AO-1 stage-II proposals. This solicitation is for budget support of US INTEGRAL Guest Observers. Proposals were collected in February 2002. A US INTEGRAL Users Committee was established, and a peer-review of the stage-II proposals is currently being coordinated by the GoF. Planning is underway for accommodation of copies of the INTEGRAL public data archive and software repository at GSFC for support of the US user community.
1. Research: I have continued to participate in two scientific collaborations, both related to the study of spectral and temporal properties of accreting black hole X-ray binaries. This has led to the publication of three journal articles, and submission of a third. In one case, we presented the time evolution of the broad-band spectral energy distribution from radio to hard X-rays, including unprecedented EUV coverage. In another article, recently accepted by ApJ, we discuss possible connections between spectral-temporal properties of black hole binaries. In a recently completed manuscript, we perform extensive temporal analysis, including tomographic imaging (from X-ray-to-optical signal delay structure) of the accretion disk, and cross-correlation analysis of the UU-optical to X-ray time series. In addition, I authored a review article on the CGRO mission for the Gamma 2001 proceedings volume (for which I was one of the editors), as well as presenting two papers at that conference. I presented papers at the January AAS meeting and at the April AAS-HEAD meeting on light-curve analysis of X-ray nova. I was also the PI on two successful Guest Observer proposals (RXTE and FUSE), and a co-I on a successful INTEGRAL AO-1 proposal. I submitted two XMM proposals (one as PI), and one Chandra proposal; these are all currently undergoing peer review. Finally, I served as a referee for a large ApJ Supplements article on methodologies for CGRO data analysis (this was a long and protracted effort, the details of which may be inappropriate to reveal here).

#### **ACTIVITY 661-03: INTEGRAL**

##### **DR. STEVEN STURNER:**

1. I have succeeded in accurately simulating the SPI calibration data taken at Bruyere Le Chatel. This was very important for our efforts to produce accurate response matrices for SPI using our Monte Carlo simulations. To achieve this goal, improvement was necessary throughout the entire simulation pipeline including:

- a) Improvements to the SPI mass model. During the last year I have made significant improvements to model of the SPI coded mask, the plastic scintillator module, the cryostat, and the detector modules including the germanium crystals. These improvements required significant time but were necessary to accurately simulate absorption and scattering within passive materials in the mass model and to improve the simulated detector efficiency.
- b) Improvements to the Bruyere Le Chatel calibration site mass model. We found that the collimator used for the calibration runs was leaky. Thus photons scattering within the collimator and the calibration room significantly altered the recorded spectra in SPI. This led to the production of a detailed mass model for the collimator and made it necessary that our simulations generate photons into  $4\pi$  steradians at the source instead of just into the opening angle of the collimator. This led to very long simulation runs. The simulation for each calibration run was then 10-15 cpu days.
- c) Improvements to the MGEANT Monte Carlo simulation package. I added two major improvements to MGEANT: including the effects of the kinetic energy of atomic electrons when performing kinematic calculations for Compton scattering and including information necessary for accurately performing the shield veto in our SPIHIST histogramming program. These improvements were necessary to accurately describe the continuum portion of the calibration spectra. We are currently investigating methods for incorporating the functionality of the Pulse Shape Discriminator (PSD) in our pipeline.
- d) Improvements to our histogramming program, SPIHIST. I worked with our programmer Sandhya Bansal to implement a change to this program so that simulated photons, which interacted in more than, one detector would be treated as separate events. This was done so that we could histogram our simulated data in exactly the same way as the program that histogrammed the calibration data. After Ms. Bansal departed GSFC, I changed the implementation of the shield veto within SPIHIST so that it used the additional shield event information being recorded by MGEANT and thus better simulated the true SPI veto process.

At each stage of development we performed simulations which were then compared with calibration data. Some preliminary results of this work were presented at the SPI team meeting in July 2001 by Dr. Teegarden and more complete results were shown by myself at the SPI team meeting in December 2002.

2. I produced several test data sets and instrument response functions (IRFs) throughout the past year for various purposes including imaging analysis of calibration data, testing of imaging software, testing of spectral analysis software, simulations of SPI diffuse emission maps, and testing of the analysis pipeline at the INTEGRAL Science Data Center (ISDC). New datasets were produced upon request from our various collaborators and when improvements in our simulation pipeline warranted them.
3. I have helped Dr. Weidenspointner develop tools within MGEANT and SPIHIST that were needed for his work in modeling the gamma-ray background in TGRS and SPI. This modeling is proceeding well with the results being presented at the January 2002 American Astronomical Society and the April 2002 American Physical Society meetings.
4. I have been working with Dr. Dodoo to evaluate the accuracy of our SPI mass model by comparing the masses of various parts of the mass model with the masses of the flight model parts. He has determined that our mass model has a total mass of 1083 kg with the actual SPI hardware being ~1300 kg. By comparing the masses of individual pieces for which we have tabulated values, he has determined that the mass missing from the MGEANT mass model is most likely exterior to the SPI veto shield and is thus of less importance to the model.
5. My research on the SNR IC 443 has concentrated on spectral and timing analysis of RXTE data. The spectral analysis is complicated because I am interested in the nonthermal spectrum above ~7 keV. In this region background subtraction is important. Early background models from the RXTE GOF proved unsatisfactory for analyzing this portion of the spectrum. A more recent model led to the results I presented at the Gamma 2001 conference last year in which I found that the nonthermal spectrum was well characterized by a powerlaw with index 2.2. A new model has just been released in 2/02 which produces different results, a cut-off to the power-law is indicated at ~10 keV. I am

currently validating these results. I have also done an extensive search for periodic pulsation in the IC 443 using Fast Fourier Transform (FFT) software. I found no evidence for coherent pulsations from a rotation-powered pulsar whose presence is indicated by Chandra imaging observations of IC 443.

My research with Dr. Glenn Allen (MIT CSR) has focused on modeling the multiwavelength spectra from young SNRs such as SN 1006 using a modified code I originally developed for modeling the emission from IC 443. In this research I use this code to produce a set of spectra for a range of primary electron spectral indices. Dr. Allen will then fit these spectra to the SNR data to ascertain the primary electron spectrum present at the source. Dr. Allen presented initial results at the April 2002 American Physical Society meeting.

I have aided Drs. Berrington and Dermer (NRL) to adapt my SNR simulation code for use with clusters of galaxies. In this mode the code assumes that the primary electrons and protons are generated near shocks caused by the infall of gas to the cluster core. These primary particles then produce radiation via the same mechanisms present at SNRs. Dr. Berrington presented results of this work at the Gamma 2001 meeting last year.

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#### **DR. GEORG WEIDENSPONTNER:**

1. In the past my activities were mainly focused on simulating the line and continuum backgrounds of TGRS/WIND and SPI/INTEGRAL. To do so I am, in close collaboration with Drs. M. Harris, USRA/GSFC, C. Ferguson, University of Southampton, UK, and Ch. Zeitnitz, Universit. at Mainz, Germany, extending existing and developing new software to include -ray line production from radioactive decays and prompt de-excitations, respectively. Within this group, Dr. Harris is concentrating on detailed line identifications in the TGRS (and simulated) data and the calculation of the probability distribution of excited states and initial transitions after various hadronic processes. The role of the other members is outlined under "University Collaborations" below. This collaboration, which I am leading, has been very successful and we hope to continue our efforts.

As a first step I merged the MGEANT code developed at GSFC (which is a user-friendly shell around the GEANT Monte Carlo package developed at CERN, Switzerland) with the DECAY code written at the University of Southampton. DECAY is a database and software to simulate radioactive decays, including an adaptation of ORIGEN (an Oak Ridge National Laboratory code for calculating build-up and decay of activity). I also introduced new and corrected old beam and spectral models into MGEANT. We then debugged and improved DECAY by adding the treatment of isomeric levels and extending and correcting the database; we also included improved neutron cross sections for Ge into our code. Currently we are working on the second step, which is to include prompt de-excitation photons in the simulations. At the point of writing this report prompt photons from neutron capture (i.e. n, reactions) are implemented for a selection of isotopes abundant in Ge instruments. We are now building the necessary data base and software for simulating prompt de-excitation photons due to inelastic neutron scattering and spallations from a large number of nuclei, both stable and unstable. These simulation tools, as they evolve, are applied to simulate the instrumental line and continuum backgrounds of TGRS/WIND and SPI/INTEGRAL. Comparison of the simulation results with TGRS data provides guidance as to which physical processes still need to be included or improved. First results and comparisons were presented in a poster at the AAS meeting in Washington DC in January. The very good agreement between the TGRS simulations and the data (the overall continuum is reproduced within 30% or better, 80% of the identified TGRS lines are produced, many of them within a factor of 2 (with no free parameters!)) gave me confidence to apply our tools to SPI. The simulation of SPI is of great interest for a number of reasons. Of scientific interest are, among other issues, a realistic prediction of the instrument sensitivity and detailed insight into the instrumental background that can be exploited for astronomical analyses. Equally important, these simulations provide guidance for optimizing the instrument tuning, e.g. by predicting the required telemetry rates in different instrument configurations (which may result in different sensitivities).

First results of SPI simulations were presented at a SPI meeting in Toulouse last month. An update of the TGRS simulations (the overall agreement in both lines and continuum improved) will be presented at the HEAD meeting in late April. In a few months the simulation code should stabilize and then the

focus will move towards application. For example, TGRS provides an excellent database for measuring the spectrum of the diffuse cosmic hard X-ray and soft -ray background. It may even be possible to search for supernova signatures in this spectrum { which have not been detected to date. INTEGRAL is supposed to be launched in October this year. Simulations will help tuning the instrument, and then simulations will be very important for developing instrumental background models for spectroscopy and/or imaging, a prime example being the study of diffuse line emissions from the galaxy due to annihilation or the decay of  $^{26}\text{Al}$ . Finally, developers of new experiments such as the NCT (PI Prof. S. Boggs, UC Berkeley) can profit from detailed simulations.

2. SPI was calibrated in April/May 2001 in France. In the months afterwards I remotely processed at CERN those data needed to study the instrument response (effort lead by Dr. S. Stürner, USRA/GSFC) and instrumental lines. By comparing room background data from monitoring Ge detectors with SPI background data it was possible to clearly identify a number of internal background lines in SPI. Some of these result for example from expected, tiny Uranium and Thorium contaminations of the high purity Be used to manufacture the SPI detector cryostat.
3. On a low level I am working on a "cosmic AGN toy model" that can be used to estimate how many AGN will be detected in the BAT survey, their typical spectra, their  $\log N$ - $\log S$  and redshift distributions, etc. First results were presented by Dr. H. Krimm (USRA/GSFC) at the Swift science meeting this February. The BAT all-sky survey will provide a unique opportunity for determining the local AGN space density and luminosity function which, combined with models for the cosmic evolution derived from deep Chandra and XMM surveys, will allow us to improve modelling of the extragalactic X-ray background..

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## **ACTIVITY 661-04: Transient Gamma Ray Spectrometer (TGRS)**

### **DR. MICHAEL HARRIS**

In collaboration with Dr. Georg Weidenspointner, I am undertaking a measurement of the cosmic diffuse  $\gamma$ -ray background - the isotropic flux between 0.1-10 MeV from the Universe at large. This probably arises from the sum of all galaxies, and may contain detailed information about the history of the Universe since stars began to form. For instance, Type II supernovae (SN II) resulting from massive star evolution produce a  $\gamma$ -ray line at 0.847 MeV. The sum of all past SNII on our light-cone would appear as a shelf at 0.847 MeV (due to the distribution of line redshifts) whose shape would contain information about the rate at which massive stars have been formed ever since star formation itself began.

Measurements of this spectrum in our energy range is extremely difficult, because there is a huge internal  $\gamma$ -ray background flux from the instrument itself and the spacecraft, arising from radioactivity induced by high-energy cosmic ray bombardment in orbit. Nevertheless, TGRS has a good chance of measuring the cosmic background, because it was exposed to as much of it as possible ( $2\pi$  steradians) and because its exposure to the cosmic rays was almost constant throughout the mission. The internal background therefore did not change much, making accurate simulations of it possible. Our first mission, therefore, has been to understand and reproduce the internal background. This work is of direct relevance to the forthcoming ESA mission INTEGRAL, which will have a spectrometer of the same material (germanium), and an orbit experiencing similar irradiation.

Dr. Weidenspointner has acquired a suite of large Monte Carlo codes which, given a model of the instrument's mass distribution, will simulate the induced radioactivity. We have undertaken the very ambitious goal of making an essentially exact, a priori calculation of the internal background which, when subtracted from the total TGRS spectrum, will yield the cosmic diffuse contribution; it is like subtracting two large numbers to a level of a few percent. My own task has chiefly been to supply a great deal of nuclear physics data necessary for this. The very rich TGRS spectrum has required a great deal of very detailed work this year.

In the past year, we have completed the TGRS mass model.. I have compiled a TGRS spectrum that is optimized for background measurements, from early in the mission when instrument performance was at



is best. I have continually revised the inventory of  $\gamma$ -ray lines in this TGRS spectrum in the light of the nuclear physics updates described below.

The cosmic ray irradiation produces nuclei in highly excited states, which decay through multiple energy levels to the ground state - a "cascade". If sufficiently excited, particles may be emitted, especially neutrons, which react further with the instrument and spacecraft. Our approach has been to treat the nuclei that are close to, or actually within, the instrument in greater detail, since they contribute most strongly to the line spectrum (germanium isotopes, aluminum and the elements in stainless steel).

I have calculated (from data in the Brookhaven Lab. Evaluated Nuclear Data File, a standard source) the branching ratios in the cascades, and compared them with the TGRS line intensities; mismatches indicate the presence of unknown blending lines, which I then identify. I have determined which nuclei are especially likely to emit neutrons when hit, that a factor that is poorly treated in the codes. For the subsequent interactions of these neutrons, I have compiled detailed transition probabilities from several sources.

Some of these data are applicable to all reactions, not just neutron-induced. I have identified energy ranges where nuclear energy levels have never been measured. At these energies, I have obtained semi-empirical formulae for the average density of levels. The known energy levels have characteristic spin and parity quantum numbers, which must be compatible with those of lower levels in the cascade. Many spin/parity assignments are not uniquely determined, and I have assigned them level by level by various probabilistic methods. I have identified energy levels that are metastable (not decaying on the usual nuclear femtosecond time-scale. If they reach microsecond time-scales, the TGRS detector distinguishes them from the total cascade, thus they appear strongly in the spectrum).

The final result of all this is a simulation of the TGRS spectrum whose continuum agrees with the measured one to within about 20%, and whose lines agree with about 50%, without the use of any free parameters at all.

## **ACTIVITY 661-05: Advanced Composition Explorer (ACE)**

### **DR. ERIC CHRISTIAN:**

1. Co-I on High Energy Cosmic Ray groups SR&T program. Support of ongoing balloon projects, specifically TIGER and NIGHTGLOW.

TIGER: I am Goddard Instrument Manager for TIGER (Wash U. is the PI institution). Over the last year, this has been my major effort. Getting the instrument ready to ship to Antarctica for the Dec/Jan balloon flight required a large amount of time early in the year, including trips to both Washington University in St. Louis and Palestine, Texas for integration of the TIGER instrument. I spent two months down in Antarctica for the launch, and I was also in charge of the TIGER Antarctica expedition for the few weeks the PI was not present. The balloon flight was a phenomenal success, both scientifically and in the area of Education and Public Outreach, and I had a major role in both, but especially the later. The record-breaking flight had two press releases and a large amount of press coverage and I think I can safely say that I was extremely important to both the scientific and outreach successes.

NIGHTGLOW: Nightglow is a balloon payload that is designed to look at the UV atmospheric background for OWL. It will be having a second flight attempt from Alice Springs, Australia in December 2002. I'm responsible for the onboard and ground command and data handling systems, and I will in the field for the Australia campaign. The instrument has undergone some modification since the flight attempt in early 2001 (the instrument worked, the balloon failed), and I have been working on software improvements and the changes needed due to the instrument changes.

3. Co-Investigator for the Heavy Nuclei eXplorer (HNX).

HNX is a Small Explorer that was accepted for a Phase A study starting May 1, 2001. One of the two instruments is the spaceflight version of the TIGER balloon instrument. I was very active in the work

and writing needed for the Concept Study Report submitted in December 2001. I am now spending a large fraction of my time preparing for the site visit in mid-May.

3. ACE Deputy Project Scientist

I think I've done well in my task as ACE Deputy Project Scientist, although this doesn't require as much time as it did before launch and when Jon Ormes was Project Scientist (Tycho von Rosenvinge is now Project Scientist). I had a major role in writing the report for the ACE Senior Review, which was rated very highly by NASA HQ resulting in healthy continued funding for ACE for the next 2-4 years. I am the ACE Public Outreach lead, and I'm responsible (author and curator) for the Goddard ACE World Wide Web pages. I continue to support the Cooperative Satellite Learning Program and the high school that has "adopted" ACE, and traveled to Old Bridge, NJ once this year.

4. Instrument Investigator for CRIS and SIS instruments on ACE

My major task on ACE data analysis has been comparing the energy fluxes obtained for Anomalous and Galactic Cosmic Rays with CRIS and SIS with other instruments and spacecraft, and trying to understand modulation both spatially and temporally. I have also been looking at solar flares, searching for a rare isotope ( $^7\text{Be}$ ) that has been seen in the Earth's atmosphere and may come from solar energetic particles. Because of balloon campaigns, I have not had as much time to spend on ACE as I have in previous years.

5. Independent Research on Heliospheric Physics

Anomalous cosmic rays with Voyager Cosmic Ray System.

Theory of modulation.

Darkening of cometary bodies in the Kuiper belt by cosmic rays.

6. Co-Investigator for Orbiting Wide-angle Light-collectors (OWL).

OWL is a future mission to study the highest energy cosmic rays by looking down on the nitrogen fluorescence in the air shower from above. My primary work has been outreach (web pages, etc.) and helping prepare presentations to NASA HQ and various committees to try and get this program in the cue.

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**ACTIVITY 661-09: International Focusing Optics Collaboration for MicroCrab Sensitivity (InFOC $\mu$ S) and Swift**

**DR. HANS KRIMM:**

1. Swift BAT Ground Software management. I have taken on the role of assistant leader for BAT Ground Software development. I run and set the agenda for weekly meetings attended by an average of eight scientists and programmers. In these meetings we discuss analysis philosophy, software interface issues and data formats. After compiling input from the BAT software team, I wrote the BAT Ground Software Requirements Document, which is the official summary of the software, data products and procedure for the analysis of the BAT science data. This document was recently signed and submitted to the Goddard Centralized Configuration Management System. I am now co-writing the document describing the detailed format of the BAT data products and have contributed to a number of other documents including the BAT-HEASARC Interface Control Document. I work with members of the HEASARC, the Swift Science Center, and the Science Data Center to make sure that all interfaces are defined and that programmers and scientists have all the information they need to develop their software. My next major task is to develop the procedures for verifying the ground analysis software as part of the Swift Mission Readiness Review.
2. Swift BAT hard X-ray survey software development. I have primary responsibility for developing the software needed to carry out the BAT hard X-ray survey. In a series of meetings and email discussions over the past six months I have worked with the BAT Science Team to define how the survey will be carried out and how the analysis will proceed. This definition period will culminate in August in a one-day international workshop on the BAT survey that I am starting to organize. As we develop the survey plan I am modifying the basic imaging and survey code and transforming it from

prototype to mature code and eventually to an FTOOL which will be used in the production processing of BAT science data as well as by external users. In order to understand the survey sensitivity and to anticipate what systematic factors most impact this sensitivity, I am continuing to develop and run Monte Carlo simulations of the BAT. I added software to include detector variations in response to the Monte Carlo. I have presented preliminary results of these simulations at the February Swift Science Team meeting and at an international conference (see below under Papers Presented). Until January 2002, I advised a UMD graduate student (see below under University Collaborations).

3. Swift Science Team member. I participate in weekly meetings to discuss BAT scientific and technical issues and have helped define the procedures for calibration of the BAT instrument and analysis of the calibration data. I contributed several sections to the document describing the BAT coordinate systems used in testing and analysis and am working to define the sky binning to be used in the hard X-ray survey. I participate in biannual Swift Science Team meetings and in frequent meetings with our colleagues from Los Alamos National Laboratory, England and Japan. I served on the USRA search committee to find a new scientist to work on the BAT program. I reviewed the original advertisement, read all applications, helped organize three interviews and candidate presentations and participated in the final decision about offering the job.
4. InFOC $\mu$ S scientific and field campaign work. The 2002 InFOC $\mu$ S balloon field campaign lasted from May 17 to July 7 and culminated in a successful flight of the telescope from Palestine, Texas. In the field I ran daily meetings of the science and engineering teams, completed development of the star camera GSE, calibrated the star camera and helped to determine the true alignment between the star camera and X-ray telescope axis and the transformation matrices between these axes. I also helped to oversee the assembly and testing of the electrical and mechanical systems and modified the mission GSE. During the days immediately preceding the flight I worked with the engineering team to test the pointing system and to develop pointing related flight procedures. I helped finalize the observing plan and helped develop and review the overall flight operations plan. During the flight I operated the star camera, analyzed the camera data in real time and used the results to instruct the pointing team how to reorient the instrument. Upon return from the field I reduced all of the data from the star cameras and created FITS image files and summary files from this data. I used the star camera data to correct the instrument pointing, which allowed the InFOC $\mu$ S science team to derive a hard X-ray image of Cygnus X-1. I also helped the engineers from the Guidance, Navigation and Control (GNC) branch analyze the data from the attitude sensors and the graduate students to analyze the spectral and attitude data.
5. Development of improvements to InFOC $\mu$ S. I took a major role in writing the proposal for the next three years of funding for the InFOC $\mu$ S mission (see below under Proposal Activity). This involved summarizing our Accomplishments: of the past three years, reviewing and bringing up to date the scientific sections of the previous proposal and editing most of the overall document. I recalculated the instrument sensitivity based on flight results and projected improvements to the mirror and detectors. I also worked with the GNC engineers who ran simulations of the instrument to help determine what additions and modifications will need to be made to the pointing system in order to correct the pointing problems found in the July flight. I also participated in extensive discussions of how to improve the InFOC $\mu$ S detectors and mirrors. After returning from the flight I undertook a review of the current state of the experiment and circulated an overall list of improvements needed for future flights. Funding constraints have required us to postpone implementation of most of these improvements.
6. Other scientific research and outreach work. I presented a paper at an international gamma-ray burst workshop on the estimated BAT sensitivity to GRB afterglows and an invited talk on Swift and GRB research at Hampden-Sydney College. I have also been asked several times to show the InFOC $\mu$ S instrument to laboratory visitors and to present its capabilities and scientific goals to various audiences. I have recruited a new UMD graduate student to join the InFOC $\mu$ S team this summer.

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## **ACTIVITY 661-13: Micro-well Detectors**

### **DR. PHILIP DEINES-JONES:**

I played a significant role in starting the polarimeter effort at Goddard this year. By good fortune, I was at the Vienna Conference for Instrumentation, where the Italian result was announced, last February. We therefore recognized the opportunity early on, and had publicly available data to make our case well in advance of their publication in Nature in June. I was also one of the two lead co-authors (with Kevin Black) on three winning polarimeter proposals last year.

We will have all of the components for a 128-pixel prototype polarimeter next month, including a micropattern detector, a readout board with 1 mil lines and spaces that is small (~2 mm) but reasonably thin (50  $\mu\text{m}$  thick polyimide), and a 128-channel readout system developed for Lobster and based on a system developed at MPE for MEGA. I developed the techniques for making the micropattern detector and the readout board. We hope to image photoelectron tracks before the end of May.

In light of the polarimeter effort, we have refocused our collaboration with Tom Jackson at Penn State to make an active readout using thin-film transistor arrays. We hope to have a large (~20 mm) active readout plane on optically thin polyimide or silicon nitride, suitable for a polarimeter, by the end of the year.

Over a year ago, we demonstrated microwell detectors that met the Lobster requirement for spatial resolution. I have been concentrating mainly on process improvements over the past year, with the result that we can now reliably fabricate 25 cm<sup>2</sup> detectors, and are confident that we can fabricate 100 cm<sup>2</sup> detectors, the size of individual Lobster panels, before year-end.

My work on silicon nitride X-ray pressure windows was turned over to our collaborators at Leicester this year, after the successful demonstration of a 3mm x 3mm 100 nm-thick pressure window.

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## **ACTIVITY 662-02: X-Ray Optics**

### **DR. KAI-WING CHAN:**

1. Preparation, development and production of 5 x-ray thin foil telescopes for the mission Astro-E2. The joint US-Japan mission Astro-E suffered a launch failure in early 2000. It was recognized that the science that would have been derived from Astro-E's unique capability would not be taken up by other planned missions and a re-flight was expected. A proposal of flying a crucial single-telescope system with the micro-calorimeter was initiated on the US side (the Joule mission, of which I was a Co-I). With the joining of the Institute of Space and Astronautical Science (ISAS) of Japan, the mission was later upgraded to Astro-E2, a complete re-flight of the original mission. My work on Astro-E2 in this period, broadly, are 1. participation in the preparation for Astro-E2's confirmation by NASA headquarter, 2. oversight of fabrication of the Astro-E2 XRT reflectors, and 3. research in improvement of reflectors positioning and assembly techniques.

A series of review processes were prepared at Goddard to obtain confirmation of the mission from NASA headquarter. I am a Co-I of the Astro-E2 mission and participated fully in the preparation of the confirmation process as a member of the XRT team. My participation includes the Site Visit (February 2001), Engineering Peer Review (November 2001), Confirmation Assessment Review (January 2002) and finally the Critical Design Review (April 2002). I worked closely with the instrument manager of Astro-E2 XRT, Mr. Curtis Odell, in the planning, technical interchange meetings, presentations, and documentation of the Astro-E2 XRT components. In particular, I am responsible for the work that are formalized in the following official documents I prepared for the Astro-E2 project:

- a) Astro-E2 X-Ray Telescope Error Budget, which details linear analysis of the various components of the uncertainties in Astro-E2's XRT angular resolution.
- b) Astro-E2 XRT Requirements (410.5-RQMT-0004), which spells out the detailed requirements of the XRT (effective area, focal length, angular resolution, band pass, mass, etc.) that will meet the high level mission requirements.

- c) Astro-E2 XRT Verification Plan (410.5-PLAN-0040), which details the experimental verification procedure of the XRT that will be carried out at GSFC before delivery to Japan for satellite integration.
- d) Astro-E2 XRT Contamination Control Plan (410.5-PLAN-0041), which is now to be integrated into the overall Astro-E2 Contamination Control Plan.

On the fabrication of X-ray telescope, together with Dr. Yang Soong of USRA and Dr. Peter Serlemitsos of GSFC, we initiate several improvements of the fabrication processes aiming to improve either the quality of the final product or the efficiency and consistency of production. These processes includes: (a) Replacement of razor-blade deburring with a rotating cutter (Peter and Yang); (b) Eliminate silicone contamination of the foil boundaries (myself and Yang); (c) Eliminate mandrel-side epoxy spraying (Yang); (d) Eliminate labor-intensive hand-washing of replication mandrels (Peter and Lawrence Olsen of Mentor Technologies, Inc.); and (e) Improve axial figure standard for replication mandrel selection (myself and Melinda Hong of Mentor Technologies, Inc.). I include a rough the division of labor, the responsible scientist, above for reference (needless to say, for a small group like ours, the division cannot be completely disjoint.) At the risk of being excessively particular, I will give a brief description of the processes, emphasizing those I involved most, below.

(a) aims to improve the consistency and efficiency of one of the most manual processes in the foil making. It is still in the work. (b) aims to eliminate the contamination due to outgassing in high temperature aluminum thermo-forming. The method is to replace the silicone based rubber gasket and adhesive with non-outgas material viton and high temperature epoxy. The replacement is unexpectedly non-trivial, due to the elastic strength of the viton sheet and rigidity of the high temperature epoxy. The process is closed to complete (90% of the gaskets are replaced) after a very long period of experimentation. The contamination is eliminated, and a whole labor-intensive process of acid-etching is entirely eliminated. (c) epoxy layer for foil replication was applied on the foil and replication mandrel in the original build, mandrel-side epoxy application is eliminated in Astro-E2 for efficiency and cleanliness of the replication mandrels. (d) Hand washing of the replication mandrel is one of the most labor-intensive processes. Attempt is made to use a machine washer with controlled cycles. The process is still under experimentation. The traditional method is being used in the current production.

- (e) Improvement of axial figure standard in replication mandrel: This is, in my opinion, one of the two most significant improvements of the Astro-E2 mirrors. The raise of axial figure standard will improve one of the most significant error of reflector resolution. In the original build, the replication mandrels were selected with a grazing incident laser beam, rejecting mandrels based on diffraction pattern. The method is useful in eliminating very bad surfaces but was not capable of selecting the very good ones---at the sub-arc minute angular resolution that we are going after. After completing an analytical study of axial figure error on mirror resolution, I proposed to further select these replication mandrels down to a peak-to-peak low frequency variation of no more than 4  $\mu$ m. These can be achieved from line scans with a high resolution laser profilometer. The study also showed that an acceptance rate of the current stock (which is already heavily selected, ~1 in 3, from the original cut) of about 10% may result. The suggestion was accepted and a massive scanning program was set up (before Astro-E2 reflector fabrication started). Over a thousand scans were made and 58 high-grade mandrels were selected out of a stock of nearly 500. The actual scans were done with the diligent and careful work of Melinda Hong. It now remains to be demonstrated that the improvement in axial figure will lead to an improvement in the overall mirror performance. Analysis of the Astro-E mirror (documented in the Error Budget document above) shows that the axial figure error is the main error source of image resolution.

Besides fabrication of XRT reflectors, on the more technical side, Peter Serlemitsos, Yang Soong and I continue to develop techniques for building/assembling a better telescope. We continue to study effect on (a) distortion of housing; which is another significant improvement in mirror performance (b) precision of positioning of the foils in the alignment structure; (c) misalignment of the assembly quadrants. (a) is largely Yang's responsibility, (b) is Peter and Yang's, while (c) is mine and Yang's. We have briefly report some of the preliminary result in an SPIE publication.

mine and Yang's. We have briefly report some of the preliminary result in an SPIE publication. Resolution measurements on more complete mirrors, to be done very shortly, will demonstrate the mirror performance in better detail.

2. Launch of the first and development and planning of the second long focal-length, multi-layered hard x-ray telescopes for the InFOC $\mu$ S.

The first InFOC $\mu$ S balloon was successfully launched in July 2001 at Palestine, Texas, and was the first demonstration of graded multi-layered, thin-foil mirror capable of observing the high energy (> 15 keV) x-ray sky. The first InFOC $\mu$ S telescope was made by our team at GSFC, with part of the multi-layer deposition done in Japan. My responsibilities in the first InFOC $\mu$ S mirror effort were in the following areas (largely with Yang Soong): logistics of foil fabrication (except the deposition of multi-layer coating), fabrication of foil substrates and fabrication of single-layer foils for deposition in Japan, and alignment of the InFOC $\mu$ S mirror. I am also part of the team to test the mirror response in x-ray (with Scott Owens then of USRA and Fred Berendse of the University of Maryland, College Park), to align the telescope (with Hans Krimm of USRA and Takashi Okajima of Nagoya University, Japan). I was at Palestine, Texas to prepare the telescope for launch.

The launch was successful, and the mirror and other instrument are recovered. The flight was short, though, due to unexpected instabilities caused by large turbulence and wind shear. The system was not able to maintain the pointing on the target but for 3.25 hours. The flux in the 20-40 keV band is measured and the spectrum is determined to be consistent with that of the targeted source, Cyg-X1. The capability of the hard x-ray telescope is proven.

InFOC $\mu$ S is planning for its second launch, scheduled in May 2003. An additional mirror will be used. This second mirror will be made in Japan, where they have also developed the capability of direct replication. This arrangement is also due to the schedule and resource conflicts of the Goddard X-ray group with Astro-E2. A third mirror (the optical bench is design to house up to four mirrors), optimized for the study of even harder x-ray (~70 keV) emission from supernova remnants, will be made at GSFC. This third flight is planned for May 2005, and the fabrication schedule shall fit nicely with that of Astro-E2. We have made a detailed proposal for the next 3-year plan for a NASA High Energy Astrophysics SR&T 2002 award. I have fully participated in that proposal and am a Co-I (Dr. Jack Tueller is the Principal Investigator.) Work is expected on testing and integration the second telescope, and also in the field (Ft. Summer, New Mexico) around May 2003.

3. Research in segmented thin foil mirror at GSFC for future high angular resolution, high throughput mission, including the glass-based foil mirrors of Constellation-X.

X-ray optics beyond that of Astro-E2 will necessarily have high throughput, high angular resolution capabilities. This is indeed a challenge taken up by the GSFC's x-ray group. Constellation-X is a major mission in that category under study. Dr. Robert Petre, head of the x-ray branch in LHEA, is leading a team to develop the technology for the first high throughput, high angular resolution telescope. The approach is thin-foil segmented optics, based on replication techniques similar to that of Astro-E2, but with different substrate and housing materials in order to meet the demanding specifications.

My work in the development of future x-ray telescopes are: (a) to provide basic support on various aspects of surface replication; (b) to participate in the design and concept development of segment alignment scheme and housing; (c) to participate in the proposal of the next 3-year plan for a NASA High Energy Astrophysics SR&T 2002 effort; (d) to continue to investigate the nature of replication with both glass and aluminum substrate. The basic facility for Constellation-X is now moved to GSFC Building 29, where a complete, and enlarged, facility is being set up. Due to the necessarily large size of these reflectors for a high throughput telescope, and the more demanding angular resolution, the alignment of these reflectors are different. I participate in the weekly discussion and other technical interchange meetings with a team of engineers, scientists and managers from GSFC and elsewhere to provide input on the design of the telescope housing/holding mechanisms.

I have also participate in preparing an SR&T proposal for the development of the high throughput, high energy resolution mirror at GSFC and I am a Co-I of that proposal (Dr. Peter Serlemitsos is the P.I.)

Even though Constellation-X is based on a glass substrate, many of the issues facing large and precise reflectors can be studied with aluminum substrate with a similar thickness of that of glass sheets. The substrates are quite substantially thicker. Glass sheet can only be formed in a one-per-mandrel fashion, whereas the aluminum sheet can be thermally formed with a much higher efficiency (~20 times, depending on the approximation taken.) Yang Soong and I are working to understand issues related to reflector figure error (roundness, for example) that is needed for the future mission.

4. Analytical research in cosmic ray astrophysics, acceleration mechanism of cosmic rays.

This is an on-going research in theoretical astrophysics with Dr. C.M.Ko of the National Central University in Taiwan. We have been using a hydrodynamical approach in studying cosmic ray accelerations. This is certainly an approximation to the more rigorous particle approach, but the hydrodynamical approach is more amenable to analytical studies, rather than numerical methods. Recently, we are incorporating models of magnetic field in the wind structure to get a more complete picture of the analysis. The work is on-going and we are preparing a manuscript for publication.

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**DR. YANG SOONG:**

1. Astro-E2 mirror fabrication is under way at the expected pace (started on January 7, 2002)
2. New schemes are being developed, showing a potential two-fold angular resolution improvement (from 1 arc-minute to 0.5 arc-minute)
3. Coordinating the work force between USRA (2 scientists), Mentor Technology (2 engineers and 5 technicians), and Goddard (2 scientists, 2 engineers, and 1 technician)
4. Three publications (1 on SPIE, and 2 on Applied Optics)
5. Support given has accelerated the preparation of the research activity (in terms of hardware and process)
6. Consultation on the hiring process (4 technicians through Mentor, and 2 scientists through USRA)

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**ACTIVITY 662-03: ROSSI X-ray Timing Explorer (RXTE)**

**DR. ROBIN CORBET:**

1. Programmatic: RXTE, Swift and Glast
  - a) RXTE is now in its 7th highly successful year of operations, continuing with a very small staff in the Science Operations Facility. In spite of the presence of the "great observatories" Chandra and XMM, XTE provides capabilities that neither of the other missions can match (and at a fraction of the cost). Some of the key capabilities include the very rapid response to Target of Opportunity requests and immediate provision of high quality scientific data to observers. Both of these are provided by the RXTE SOF operating under its very small budget.
  - b) Swift is progressing towards launch and the BAT team intend to use my software as one of their planning tools to optimize scientific return from this instrument. Several enhancements to this software have been made at the BAT team's request. In educational outreach, this software work now involves Jason Mathews, a local high school student.
  - c) GLAST is further from launch and I have contributed to Mission Operations meetings and reviews and participated in Science Support Center activities.
2. Astrophysics: Pulsars in the SMC. I continue a highly successful long term monitoring program of the SMC to find new X-ray pulsars and determine orbital periods. These measurements are expected to shed light on the evolution of the SMC and help explain why such a large population of X-ray pulsars exists in this galaxy. The success of this program has been recognized by the award of 1.65 Ms of time in the RXTE AO7 program and the award of an ADP grant to support this work (only 18% of all ADP proposals were successful). The incredible density of pulsar in the SMC is illustrated in the figure,

made in collaboration with S. Laycock, a student at Southampton who is using this data as the basis of his Ph.D. thesis. The plot shows the number of pulsars in three galaxies (the SMC, LMC, and the Milky Way).

Even though the SMC is the smallest of these three (about 1/50 the mass of the Galaxy) we now know of almost as many Be star pulsars in the SMC as in the Milky Way and, at short pulse periods, there may well be even more than in the Milky Way. Discoveries continue rapidly with 3 new pulsars found already in the first quarter of 2002. (Please note: the plot is color coded and so may not be clear on black and white hardcopy). There is a relative lack of long period SMC pulsars which we are investigating to determine whether it is due to a real lack of these objects or partially due to selection effects. (At least part of the effect is clearly real as the SMC lacks the long period supergiant wind accretion systems found in the Milky Way).

3. Astrophysics: Confirmation of the Power of the Period/Period diagram and the Potential for a Neutron Star Mass Measurement. On the basis of the source's position in the orbital period/spin period diagram, I predicted earlier that XTE 11855-026 contained a supergiant star as the mass-donating object rather than a Be star. i.e. this is one of the class of X-ray pulsars that is apparently missing from the SMC. From an RXTE PCA study I measured the orbit of this system, finding a large mass function, and discovered an eclipse, thus confining the prediction. I also obtained a very precise position using ASCA data (in collaboration with K. Mukai) which should hopefully lead to the identification of an optical or IR counterpart. If this can be found this system will be a member of the small class of "double-lined eclipsing X-ray binaries" which would provide an accurate mass for the neutron star in the system.
4. Astrobiology: Searches for Short Duty Cycle Signals in SE11. I earlier proposed a technique of using gamma-ray bursts to coordinate SETI searches for low duty cycle signals (it is now known that there are no persistent powerful signals near the favored spectral region containing the hydrogen line at -1.4 GHz). I have been working with the non-profit SETI League to undertake a ORB coordinated search and I have been invited to present a paper on this topic at the April "SETICon 2002". In addition, in a paper submitted to "Astrobiology" I have proposed a different new simple to use technique which can be used to perform all-sky surveys by observing targets at their maximum angular distance from the Sun. This technique is again based on the principle of searching for low duty-cycle signals. It is probably reasonable to expect extra-terrestrial transmissions will only have a low duty-cycle if the transmitting civilization also has budget constraints!

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## **ACTIVITIES 662-06 & 662-20: ROSSI X-Ray Timing Explorer (RXTE) & SWIFT**

### **DR. ALAN SMALE:**

#### **1. Manager of the RXTE GOF**

- a) Organized the RXTE Guest Observer Program; prepared the Cycle 7 Announcements and Appendices for NASA HQ; organized the RXTE Cycle 7 Peer Review (2001 Nov 11-13); sorted proposals, verified proposal contents, assigned numbers to proposals, divided proposals and reviewers into panels, performed technical feasibilities, assigned primary and secondary reviewers, led the logistical effort for the Review itself, and taken overall charge of the conduct of the Review;
- b) Implemented fully-electronic proposal submission and processing for Cycle 7. Electronic submission of the cover forms was achieved via RPS, with scientific justification texts submitted electronically in PostScript format. Proposers no longer had to supply 15 printed copies of each proposal.) This innovation -- along with the enforced deadline delay and compressed schedule due to the 9/11 events -- made this a particularly challenging Cycle;
- c) Oversaw the release to the community (in February) of enhanced background estimation tools, accounting for the loss of the propane window in PCU0. (I did quite a bit of testing and verification myself for this.)



- d) Continued to populate the RXTE Archive with improved Standard Products (cleaned spectra and light curves from the PCA and HEXTE, selected and background-subtracted using the best calibrations). We have now completed products from the start of the mission through to the end of Cycle 4, handily passing the half-way mark;
- e) Led data troubleshooting and community notification during a loss of (RXTE) attitude control in November 2001;
- f) Performed continuing work on archive issues, calibration, and community support. I participate on an equal footing with the other GOF members in staffing the Email hotseat, writing recipes, and testing software.

## 2. Manager of the Swift Science Center

My work on the Swift ground systems now consumes half of my programmatic time, as anticipated. I now lead a five-person team (self, Padi, Mike Tripicco, Sue Valett, Bob Wiegand) and I chair team meetings every two weeks to review progress. My Swift efforts include the following:

- a) Continued to define the role of the Swift Science Center, and design data analysis software for the UVOT instrument;
- b) Authored the SSC Requirements Document, the Swift Data Center-Swift Science Center Interface Control Document, documents covering UVOT software detailed design and UVOT FITS file formats, and the SSC development schedule and test plan;
- c) Presented the SSC plan at the Swift Ground Systems Critical Design Review in November 2001;
- d) Delved into SAS code written for the XMM/OM in search of templates, algorithms and approaches that could be followed in Swift UVOT software. Analyzed OM data, assessed image processing packages;
- e) Helped drive the development of the HEADAS -- a new next-generation modular FTOOLS structure and philosophy, more 'friendly' to missions like Swift with distributed software development;
- f) Led the Build 0 (proof-of-concept, Sep 2001) and Build 1 (Mar-Apr 2002) releases of UVOT software, and integration of instrument team software deliveries (from the Italian team) into the HEADAS system;
- g) Participated in biweekly telecons with other Ground System team members, and occasional telecons with instrument teams members and other Swift players.

## 3. Science research

- a) Observed the low mass X-ray binary X1254-690 with RXTE in 2001 May and December, and performed detailed modeling of the spectra during dips. I find that in the deep dipping that occurs in the May observation, the blackbody component is totally absorbed while a small fraction of Comptonized emission remains. Dip spectra are well-fit using a progressive covering approach in which the point-like blackbody emitter is instantaneously covered, while the extended Comptonized emission associated with the accretion disk corona is progressively overlapped by the absorber, with the covering fraction rising to 94% in the deepest portion of the dip. This is work done with Mike and Monika Church (U. Leicester, England); I'll be lead-authoring this paper. Dipping did not occur during the December observation, but remarkably, both bursting and flaring were observed contemporaneously. This will be the subject of a future paper, probably to be led by Monika.
- b) Analyzed extensive RXTE data from LMC X-2 obtained in 1997 Dec, 2001 Feb, Aug-Sep and Dec, and 2002 Feb, following up on an original investigation by Smale & Kuulkers (2000; paper [71] in my attached resume). The full dataset indicates that LMC X-2 may be a Z-source spending most of its time in the Flaring Branch with excursions onto the Normal Branch, behavior reminiscent of the Z-sources GX17+2 and GX 349+2. This would make LMC X-2 the eighth Z-source known and the first outside our Galaxy. I presented these results at the AAS in Washington DC in Jan 2002, and a paper is in progress.

- c) Co-authored (with Padi Boyd) a press release for the Pasadena AAS meeting entitled "Method uncovered in madness of black hole and neutron star eruptions" based on the poster "Disk Disruptions and X-ray Intensity Excursions in Cyg X-2, LMC X-3 and Cyg X-3" by Boyd and Smale. The release was widely referred to in spacey places like spaceflightnow.com, Spacelink, space.com, NASA Quest etc, but did not, alas, make the front page of the New York Times. A paper is now close to submission.
- d) Conducted two surveys of all existing archival RXTE data from LMXBs, searching for (a) hard (i.e. high-energy) emission tails in bursters, and (b) bright radius-expansion bursts. Tails were discovered in two or three bursters, though I doubt that's interesting enough to make a serious paper out of. No previously unknown radius-expansion bursts were found lurking in the archive.
- e) Continued to analyze incoming data for a long-term monitoring and eclipse-timing program on X1658-298 -- the paper will probably be lead-authored by Mike Wolff from NRL, since I'd rather concentrate on the projects above.
- f) Continued to be involved at the co-I level with many other science projects, providing contributions for papers, comments on drafts, RXTE expertise, etc.

#### 4. Public Outreach

While not conducted during work hours, I continue to work on community outreach through the AstroCappella project that I co-lead with Padi Boyd. Our full-length music CD and CD-ROM, "AstroCappella 2.0" was released in September 2001, with 13 original, astronomically-correct songs and CD-ROM materials including curriculum notes, lesson plans and activities for each song, movies, slide shows, etc. We continue to give concerts with our a cappella group, The Chromatics, including shows last November at the Air and Space Museum and the Maryland Science Center, and more recently at the Montgomery County Planetarium.

"AstroCappella 2.0" has been featured by Sky & Telescope, Astronomy Today, and the Baltimore Sun and is available via the Astronomical Society of the Pacific Educational Products catalog (hardcopy and online). We've sung AstroCappella songs live on the radio for "Damian's Diner" on WRNR. In March 2002 our song about the Sun was featured on NASA Connect's show "Having a Solar Blast" and our Swift song was played on the nationally-broadcast PBS show "What's In the News?" One of the songs I wrote for "AstroCappella 2.0" (A Little Bit of Rock, about comets, meteors and asteroids) was a finalist for a CARA (Contemporary A Cappella Recording Award) in the 'Music for Kids' category. More shameless promotion for the AstroCappella project can be found at [www.astrocappella.com](http://www.astrocappella.com).

### **ACTIVITY 662-07: High Energy Astrophysics Science Archive Research Center (HEASARC)**

#### **DR. MICHAEL CORCORAN:**

##### 1. Scientific Research

Published 10 papers in refereed journals this FY (as either 1st author or co-author. Had 1 Chandra proposal accepted (Co-I), one HST proposal accepted (Co-I), and one RXTE proposal accepted (PI), and submitted 12 XMM and Chandra proposals (3 as PI, 9 Co-I), along with a review article "X-ray astronomy" for the Encyclopedia of Physical Science and Technology. Supervised postdocs Aaron Flores (CONACYT) in analysis of XMM HD 5980 imaging data and Kenji Hamaguchi (Kyoto) in studies of X-ray emission from Herbig AeBe stars. Continued monitoring and analysis of RXTE observations of Eta Car and e-mail periodic reports to community. Organize and coordinate the XMEGA group and website and coordinated analysis of XMEGA observations of NGC 3603 (Chandra) and NGC 346 (XMM); 4 papers have resulted from this collaboration during this FY. Published 2 papers on the analysis of Chandra grating spectrum of Eta Car.

##### 2. HEASARC Picture of the Week

Authored 52 Heasarc picture of the week pages and revised HEAPOW website

### 3. LHEA Seminars

Scheduled 61 speakers for Tuesday and special seminars; revised and updated LHEA seminar website

### 4. HETE2 Archive

HETE2 archive opened in February 2002. Developed HETE2 archive website and created HETE2GCN searchable browse table of HETE2 gamma ray burst announcements.

### 5. GLAST Archive

Reviewed interface requirement documents; discussed GLAST archive requirements with GLAST team members

### 6. Oversight of the ROSAT data and results archives at GSFC and associated HEASARC public access databases

Revised ROSAT public data tables and verified ROSAT archived data; reviewed and updated ROSAT documentation; began to create links of ROSAT data to published ROSAT papers with Ms. Si Tran, a Parkdale High School student.

### 7. Oversight of the HEASARC CALDB.

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## **DR. STEPHEN DRAKE:**

1. In the last full calendar year of 2001, we added or substantially modified 66 catalogs or database tables to our BROWSE database systems, compared to an average of about 40 tables per year in the three previous calendar years. In the first 3+ months of 2002, an additional 16 catalogs were added or substantially modified. This increase in the number of tables that have been created/modified is due to the more efficient database ingest system that Ed Sabol, the Browse table ingester, and I have now fully implemented. We have also 'automated' an increasingly large fraction of these tables (11 in CY2001), such that cron jobs check ascii or html tables on web pages at remote sites, such as the ISO Archive, the Chandra Archive, the Australia Telescope National Facility, etc., and then update their Browse implementations if the latter have changed.

My part in this activity has historically involved (i) working closely with the database technical person who actually runs the software to ingest these catalogs and to convert them into a BROWSEable database, and, perhaps most importantly, (ii) ensuring that these new databases are accurate representations of the original catalogs and that the help documentation accurately describes the HEASARC's online versions of these database tables. These latter activities can be very labor-intensive but are essential in order that the integrity of the original catalogs not be compromised. Indeed, in a number of cases, as a result of this verification, errors in the original tables have been found.

Given that we now offer access to all CDS Vizier tables via our Web BROWSE system, I concentrated in the last year on adding X-ray tables and general tables of wide interest, and on updating a number of our older tables which were either out-of-date or poorly structured or documented. A list of the tables created and updated in the last 6 or so months is available at:  
<http://heasarc.gsfc.nasa.gov/docs/heasarc/databases/databases.html>

2. The HEASARC's On-Line Service comprises a World-Wide Web service, including the W3BROWSE utility for browsing our databases and catalogs on the WWW, as well as the 'traditional' XOBROWSER/BROWSE service, and our Anonymous ftp server. My major OLS role is to help ensure the integrity of the data and software that is accessible to the user community, including working with the other HEASARC scientists in coordinating and improving the appearance and functionalities of the HEASARC Website. As part of this latter role, I continued to chair a series of fortnightly meetings on the HEASARC Website and BROWSE utility which address both stylistic enhancements and improvements in their capabilities. These meetings have proven very useful in helping us plan, prioritize, and allocate resources for the development of our Website and software.

I have continued to personally maintain a number of Web pages on the HEASARC site in order to help people in the high-energy astronomy community keep abreast of important new occurrences in the field:

- a) <http://heasarc.gsfc.nasa.gov/docs/heasarc/headates/headates.html> contains information on 'High Energy Astrophysics Deadlines & Events' such as Upcoming Proposal Deadlines, Previous AOs or NRAs for which Lists of the Accepted Targets or Proposals are now Available, Other Significant Events for High-Energy Astronomy in the Future, and Deadlines/Events in the Recent Past,
- b) <http://heasarc.gsfc.nasa.gov/docs/heasarc/meetings.html> contains information on 'Upcoming Meetings of Potential Interest to X-ray and Gamma-ray Astronomers' such as High Energy Astrophysics meetings, Other Selected Astronomy, Physics and Space Science meetings, and Selected Astronomy-related WWW, Computing, and Information Services Meetings,
- c) <http://heasarc.gsfc.nasa.gov/docs/heasarc/databases/databases.html> contains information on 'New, Updated and/or Revised HEASARC Databases
- d) <http://heasarc.gsfc.nasa.gov/docs/heasarc/databases/new-catalogs.html> contains a list of the 'backlog' of catalogs that are waiting to be ingested into the HEASARC system.

All four of these pages are updated typically on a weekly basis. I also maintain a couple of pages on (i) the History of High-Energy Astronomy:

(<http://heasarc.gsfc.nasa.gov/docs/heasarc/headates/heahistory.html>) and on (ii) High-Energy Astrophysics Websites (<http://heasarc.gsfc.nasa.gov/docs/heasarc/heasites/heasites.html>) which I maintain on a less frequent basis of several times per year. I have also worked with Karen Smale on developing timely alerts of breaking news of interest to HEASARC users. We now have a "What's New?" box prominently displayed on the HEASARC home page, as well as a dedicated page (<http://heasarc.gsfc.nasa.gov/docs/heasarc/databases/whatsnew.html>) which we strive to update frequently, hoping to add at least one new item every week.

3. In no particular order:

- a) I assisted Nick White in preparing an agenda for the 2002 HEASARC Users' Group Meeting that was to be held on May 6 2002 at GSFC. I also provided usage statistics to two of the LHEA projects (RXTE and XMM-Newton) that were to be part of the NASA Senior Review in Summer 2002.
- b) I served as a Panel Member and Chair for the Chandra Guest Observer AO-3 Proposal Science Review that was held in Boston, Mass. from 2001 June 18-20. As Panel Chair, I also participated in the subsequent AO-3 Budget Review for the proposals that had been approved in the Science Review.
- c) I attended a number of telecons and sent some science background on stellar X-ray flares and their prevalence and properties in late summer 2001 in support of the Skywatcher MIDEX proposal (this proposal was not successful).
- d) I assisted Tom McGlynn as a Co-I of his AISRP-funded Class-X proposal
- e) I attended a seminar on better Web design and interfaces that was given by Cornerstone Associates on Oct 19 2001 along with about 8 or 9 other HEASARC/OGIP staff.
- f) I attended a meeting of the Constellation-X Facility ScienceTeam (I am a member of one of the Constellation-X Science Panels) that was held at GSFC from November 15-16 2001.
- g) I attended two meetings of the ad hoc Astronomical Data Center Coordination Committee as a representative of the HEASARC, the first at NASA HQ (held 2001 November 1-2) where I participated in the fine-tuning of a presentation that this group made to Dr. Anne Kinney, the recently appointed head of NASA's Astronomy and Physics Division, and the second in Baltimore (held 2002 February 12) where it had metamorphosed into an officially sanctioned Astrophysics Data Center Executive Committee.
- h) I have overseen the compilation of bibliographic code ("Bibcode") versus dataset identifier tables that are to be used by ADS to create Web links. These links will enable users of ADS who have

selected a paper in which they are interested to access the datasets which were analyzed in that paper, and (if desired) to repeat and verify the analysis. As of the time of writing, these Bibcode tables were complete for XMM-Newton (refereed) publications, and in progress for ROSAT and ASCA publications.

4. My high-energy astronomy research has essentially continued the analysis of X-ray emission and spectra of coronal-type stars that I have discussed in previous summaries of Accomplishments:, and I have also revived my dormant radio astronomy research, primarily in support of the high-energy observations (radio data provide valuable information on magnetic field strengths and the non-thermal particle populations, whereas X-ray data constrain the thermal particles and their properties) .

The only 'new' dataset that I analyzed was a 35,000 second XMM AO-1 observation of the nearby inactive K giant Beta Gem (Pollux) that took place in spring 2001. This star was 4 times weaker than in previous Einstein (in 1979) and ROSAT (in 1990-91) observations. I speculate that this variability may be due to an activity cycle phenomenon similar to that known for the Sun and many other solar-age main sequence stars in the solar neighborhood, although other explanations are possible. The low X-ray flux level of Pollux combined with the softness of this spectrum meant that only ~700 counts were accumulated, far too few to do a detailed spectral analysis, but a single-component MEKAL plasma model in which the N and O abundances are allowed to vary fits the observed spectrum well (reduced chi-squared of 1.02 for 57 dof) and implies a temperature of 1.7 MK and a coronal N/O ratio of 0.42 dex greater than the solar photospheric value, which is consistent with Pollux's measured photospheric value of 0.56 dex solar. When the data from the second observation (of the subgiant Beta Hvi) in this program have been received and analyzed, I intend to present a poster on this project at an upcoming meeting.

My analysis of the two approved targets that I had been granted as part of the Chandra AO-1 GO program continues. I presented a poster on the results of a preliminary analysis of the Chandra HETG spectrum of the RS CVn binary UX Ari observed at a time when the coronae of this system were extremely quiescent, at the Cool Stars Workshop in Boulder, Colorado held from July 30 to August 3 2001. The results of this Observation confirmed, inter alia, that high Neon abundance is apparently a universal phenomenon in active stellar coronae. My Chandra AO-3 observation of HD 155555 is to occur in July 2002.

I worked with Stephen White (U. Maryland) on completing a project studying the radio properties of about 20 nearby very-low-mass stars, including some possible brown dwarfs (objects that never have or will undergo fusion of hydrogen in their cores). We failed to detect any of these objects as radio emitters, but the upper limits should still provide useful constraints on their radio brightness temperatures and flaring frequency.

5. My work in updating and maintaining the EUVE Archive resident at the HEASARC continued, with the last proprietary datasets from this mission being made public on Oct 1 2001. All of the primary mode, pointed data, with the exception of about a dozen datasets that the Center for Extreme-Ultraviolet Astrophysics (CEA) never sent to either the HEASARC or the NSSDC, are now available at the HEASARC in our ftp area, and most easily accessed using our Browse utility. A small number of special-purpose datasets in scan mode or engineering mode are also available in our ftp area. I continued working with Karen Smale to finish up the HEASARC's EUVE Archive Website. Early in 2002, I fixed a number of links broken when CEA closed, mostly by redirecting them to the Multi-Mission Archive at the Space Telescope (MAST), MAST having copied most of the CEA Website including the useful Interstellar Column Density tool.

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**DR. TOM MCGLYNN:**

1. Develop and support interfaces to HEASARC data and software resources.
  - a) Led several major new releases to the Browse operating system:
  - b) Integrated the thousands of CDS Vizier catalogs into Browse. This represents the largest seamless integration of distributed resources in the astronomical community.

- c) Provided access to major new catalogs including the GSC2 and 2MASS catalogs each of which has hundreds of millions of entries.
  - d) Linked to popular services from within Browse including tighter links with SkyView as well as links to external services such as NED and SIMBAD.
  - e) Recast the entire system into a new object-oriented framework.
  - f) Continued support for Astrobrowse data location service
2. Represent the HEASARC in the development of community resources for accessing astronomy information.
    - a) Led USRA/HEASARC in NSF NVO proposal team including major responsibilities for metadata profile development.
    - b) Established and led ADEC ITWG to spark development of NASA archive centers interoperability.
    - c) Participated in Opticon Interoperability Working Group.
    - d) Participated in NASA HQ Science Archive Working Group (SAWG)
  3. Lead the ClassX collaboration in the development of an automated X-ray object classifier.
    - a) Led multi-institute collaboration.
    - b) Developed preliminary samples and classification algorithms
    - c) Presented results at AAS, ADASS and AVO meetings.
  4. Continue the development and support of the SkyView virtual telescope.
    - a) Received 'permanent' funding for SkyView secured.
    - b) Released DSS2 and HRI surveys.
    - c) Transferred systems to new servers, providing first HEASARC experience with use of Linux for Web servers.
  5. Provide generic support to the HEASARC and astronomical community.
    - a) Continued development of FITS support tools for IDL and Java including completion of MWRFITS program for writing FITS files in IDL.
    - b) Enhanced to ROSAT exposure calculation program.
    - c) Participated in HEASARC User Group reviews and other HEASARC planning activities.
  6. Perform astronomical research.
    - a) Transferred SkyMorph to new SkyView hardware.
    - b) Fixed NEAT astrometry data.
    - c) Enhanced moving object capabilities within SkyMorph
    - d) Helped develop tools to enable detection of moving and variable objects in NEAT archives.

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## **ACTIVITY 662-10: Advanced Satellite for Astrophysics and Cosmology (ASCA)**

**DR. KOJI MUKAI**

1. I am continuing to work with Dr. Dotani at ISAS and Dr. Yaqoob at JHU on ASCA SIS final calibration. I have made numerous test versions of SIS response generator for this purpose. In particular, we have been able to refine the thickness of SIS active and dead layers by fitting ASCA GIS and SIS spectra (as well as Chandra grating data) using these test matrices.

2. I have been attending Astro-E2 team meetings, both the international Science Working Group meetings and local at GSFC meetings, to monitor the progress of the hardware efforts, and to plan for software development.
3. I have been able to carry out more scientific research during this period, in the publication and proposal lists below.
4. Ask a High Energy Astronomer service continues to receive about 200 questions per month; I have coordinated the team of hotseaters, and updated the archive to reduce overload of questions.
5. We have been able to answer most incoming questions from archival ASCA data users within a day or two.
6. I have released PIMMS 3.2 during this period (and probably release PIMMS 3.3), incorporating latest XMM and Chandra calibration updates.

## **ACTIVITY 662-12: X-Ray Multi-Mirror Mission-Newton (XMM-Newton)**

### **DR. ILANA HARRUS:**

1. For the XMM-Newton GOF, I have written codes to allow users to create images from the OM files given by the processing. The concept was inserted in the newest version of the SAS software released. I have presented this software at public software demonstration (AAS, January 2002, DC). The code is available on the Web. We also debug programs coming from ESTEC (SAS). Help user to analyze their data (both by e-mail and during GO site visits). We have finished the writing of the updated edition of the XMM-Newton ABC guide of analysis. Participate in the user working group meeting. Assisted GOs during the proposal writing and submission process Use the biweekly teleconferences of the OM calibration group to gather information for the US user community.
2. Presented results at meeting (ESTEC, Nov. 2001). Paper submitted accepted (Co-I). Proposal written and accepted (Chandra Ao3)- Submitted proposals for Chandra AO4 and XMM-Newton AO2. Results pending. Invited to participate in a peer review of proposals (ADP and LTSA, RXTE, Astrophysics Theory Program). I accepted ADP/LTSA (and ended not doing it) and declined the RXTE and the Astrophysics Theory Program because my schedule at that time would not allow it.
3. Involvement in the EPO effort in the Lab. Answer questions from the public (more than 300 questions from April 01 to April 02). I am part of the team working on the "Matter in the Universe" poster, have contributed to the "Extreme Universe II" CD, and to the APOD project. I also have a continuing participation in the "Image the Universe" project. I was a judge in the NASA Student Involvement Program (category Science Journalists).
4. The work for XMM-Newton EPO was less hectic than last year. The main projects (web site and lessons plans) were in place. We are keeping the site updated with News from ESA. I reviewed the science accuracy of new products. We made A) X-ray activity flyer for the Structure and Evolution of the Universe Education Forum (SEUEF) Cosmic journeys E/PO folders, B) a bookmark explaining the concept of multiwavelengths included in the SEUEF teachers kit and resource guide. Distribute locally some XMM-Newton products (magnets advertising the web-site produced at UCSB. Articles published in the press (Scientific American Web site article to be published) and professional publications (HEAD, AAS, and EPO newsletters) to increase visibility of XMM-Newton in the community.
5. The X-ray Astronomy School is a USRA/GSFC/CXC collaboration. Last year we (Sandy Barnes (USRA), Keith Arnaud (UMd) and myself) organized the school onsite in less than 3 months. I created the web site and participated to the selection committee. The response to last year school was very positive (despite the problems due to the 9/11 attacks), this year's school is already full and we have had to increase the limit of people accepted to accommodate the demand. This year's school is in a different location (in West Virginia) and will be on a first come, first serve basis (so there is no "selection committee"). The organizing team also includes Michele Barton (USRA) who created the new web site. I've been in charge of the general organization in coordination with Sandy Barnes.

6. I am part of the ASTRO-E2 EPO group in charge of the organization of the Astro-E2 competition student program. I have so far produced the guidelines for the judges and the details of the grading scheme (modeled on the NASA Student Involvement Program) -- We are exploring possibilities to have our program selected as one of the NSIP program to benefit from both the experience and the existing logistic support. We are nevertheless preparing to run the program ourselves if need be. The production of the complete brochure necessary for the judging of the competition is a major effort and is it still ongoing.
7. I was offered the position at the beginning of March 2002. I have worked intensively for the preparation of the HEAD meeting hold in Albuquerque from 20-23 April 2002.

The work consisted in:

- a) writing media alert for science journalists,
- b) selecting the news worthy abstracts among about 370 submitted,
- c) organizing the press conferences and press releases by contacting the scientists and securing their participation,
- d) preparing media kit to be distributed at the HEAD meeting,
- e) presenting the press conferences at the meeting,
- f) staffing the press room daily from Saturday to Tuesday,
- g) organizing the dry run and the press conferences,
- h) contributing to the HEAD newsletter.

Normal duties include contribution to the HEAD part of the AAS newsletter (to be published soon), organizing future releases and press activities, and directing the complete selection process of the Schramm award (award for science journalists).

8. I'm on the help desk of ASCA -- answering almost exclusively question about a program I wrote during my first year at GSFC and which is used to mosaic separate observations. I also maintain the program on both Solaris and Linux platforms.

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#### **DR. STEVEN SNOWDEN:**

1. The XMM-Newton GOF is functioning quite well. Support activities over the last year have included the creation of the US data archive and distribution of GO and GT data to US PIs, creation of an "ABC Guide" for the analysis of XMM-Newton data, distribution of GO grants for successful AO-1 proposals, support for the AO-2 science proposal submission process, and of course, directly aiding the US users community through helpdesk, visitor, and outreach activities. My contributions were the over-all direction of the GOF, oversight of the grant distribution process, general editor of the "ABC Guide" and authorship of the Introduction and EPIC sections, and support of the users community through the helpdesk, a SAS (SAS is the XMM-Newton data analysis software package) workshop at the Washington AAS meeting, and producing and providing documentation and information through the WWW. This year we were required to submit a proposal to the Senior Review process for support of the XMM-Newton GSFC GOF. I was an editor for this opus.
2. In the last year I participated in the US XMM-Newton Users Group meeting (I am an ex-officio member) at the Washington AAS meeting. I attended the EPIC Calibration/Operations meeting in Germany, and will attend the June XMM-Newton SSC meeting in Britain. The Cal-Ops meeting was very useful to learn the current calibration status of the EPIC instruments while the SSC meetings are very useful to gauge the status of the SAS. At the Cal-Ops meeting I presented updated results on my cross-calibration studies between XMM-Newton, Chandra, ASCA, and ROSAT. Supporting the public release of SAS was a big issue earlier this year with SAS V5.3. Having an external test site is clearly required both because the system will not have built in assumptions (e.g., specific logicals and paths) and because different people are likely to test the software in different ways. A number of bugs were found, and reports filed.



3. I updated the QuickSim observation simulation program for AO-2 using up-to-date calibration data and worked to create a cosmic background simulation Ftool.
4. Since the last report, I've had three co-authored either published or accepted for publication in refereed journals.
5. The ESAS software package continues to be extensively used in the ROSAT community, and it is still the only means of undertaking the analysis of certain aspects of ROSAT observations (the soft X-ray diffuse background and large-scale extended sources). Currently all that I'm doing with this software is general maintenance and answering a few questions now and then. During my trip to Germany I found out that the ability to cast new maps from the diffuse background data that was the result of my post-doc at MPE, is now a lost art (the software and data files were specific to the VMS system). I am now trying to recover the ability, with some success.

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**DR. MARTIN STILL:**

1. We (the GOF) operate a help desk (by phone and email) and support Guest Observer (GO) visits to GSFC for direct interaction. Wherever possible we use existing mechanisms developed by the HEASARC for interacting with the community in order to provide continuity with previous missions. We communicate with the general US scientist via electronic status reports, booths at major science meetings and through the US User committee that we have set up. We organized a data analysis workshop at the Washington AAS in January and plan another one at GSFC later this year.
2. We supported the AO-2 proposal process for US users. This AO was heavily oversubscribed by 9:1, with 25% of worldwide astronomers involved in proposal applications. Despite this, a third of all proposals had a US principle investigator and two thirds have US involvement. After the TAC meet in June, it will be our responsibility to organize the AO-2 budget proposal process and distribute GO funds.
3. We have authored the XMM-Newton ABC Guide. This document has been quickly adopted as the primary reference for XMM data analysis and is distributed with each disk of Guest Observer data by ESA.
4. Our efforts in bench-testing development versions of the XMM analysis software for ESA programmers using flight data means that we provide a significant role in the producing of software for community consumption.
5. The support of RGS data analysis has required special attention this year. It became apparent that the OGIP data format was not flexible enough to support RGS spectral files properly. We have modified the format to produce a new, more flexible OGIP standard. Also, a major advantage of the RGS is its ability for high resolution spectroscopy of extended sources. However, there is no XMM software for this type of analysis. Working with the Columbia instrument team, we have been creating a community-friendly tool for spectral analysis of extended sources for release in the next HEASoft package.

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**ACTIVITY 662-18: Education and Public Outreach**

**DR. JAMES LOCHNER**

1. My chief work continues to be the development and maintenance of the Imagine the Universe! Web site and its related activities. This has included routine updating of Imagine site with news features, satellite showcases, a new featured scientist, and videos. I accomplish much of this work by managing a small, but dedicated, team consisting of a web programmer (1.0 FTE), graphic designer (0.2), curriculum developers (0.75), science writer (0.2) and product distribution manager (0.75). Scientists in the Lab also contribute their time to developing and reviewing scientific content.

A large effort goes into producing the annual CD capture of the web site in Dec and Jan. In preparation for this year's edition, we made a number of improvements to the site based on production

of last year's edition and lingering issues from the evaluation and redesign of the site in 2000. This included providing better linking for some of the articles (especially those with multiple sub-articles), unifying formats and content for information in the side-bar, providing a "printable page" feature, reviewing selected articles for readability, and providing captions for all the images. In addition, we also worked to make the site "section 508" compliant.

As with previous years, the CD contained Imagine, StarChild, and the previous year's Astronomy Picture of the Day. Working off our success from previous years, I organized a team of 8 editors to edit the APOD pages in the fall. The 3 sites were captured in Dec 2001, and the CD sent to print in mid-January. We received the completed CDs in late Feb, and distributed 3500 of them at the NSTA meeting in San Diego, CA in late March. We also sent 500 to the ITEA meeting in mid March, and 1500 to the NCTM meeting in mid April. We expect to distribute the remaining 20,000 CDs through the course of the year via workshops, email requests, OSS Broker/Facilitators, NASA Education Resource Centers and Aerospace Education Specialists, and regional teacher meetings.

An ongoing effort is to complete various sections and features of the Imagine site. Working with Barbara Matteson, we have made progress writing the "data" portion of the "Satellites and Data" section of the web site. During the summer of 2001, I worked with teacher intern Cheryl Carter (Bladensburg High School) to develop additional "Try This" activities. For each of the Imagine science articles, these short activities extend an aspect of topic. About half of the articles lack a Try This activity. Ms. Carter developed 6 new activities, the most interesting of which was determining the distances to Type Ia supernovae.

In an effort to review the material on the Imagine site, during the course of the year the Imagine lesson unit, "Spectroscopy of Supernova Remnants" was reviewed and classroom tested by a group of 7 teachers in the Chicago area. This partnership was originally organized with Dr. Elizabeth Roettger (Space Science Center for Education and Outreach, DePaul Univ.). The teachers provided feedback on the background articles, and gave reports from their experiences doing the activities with their students. They gave suggestions for adapting the activities for middle school students, and for extensions on the activities. A number of their comments were incorporated in time to be included on the 6th Edition of the Imagine CD, with more included on the site as their work continued into early 2002.

In Feb. we started the next in our series of posters and information booklets. The topic is the cosmic origins of the elements and the life cycle of matter in the universe. This project is part of the E/PO program for INTEGRAL (see below), but following our usual course of not making materials explicitly mission specific, it will touch on a variety of topics in high-energy astronomy. Initial start-up involved deciding on the chief themes, investigating linkages to national science education standards, and investigating the existence of other similar material. Members of the GSFC Education office are providing feedback and input into our development. The poster and initial material will be previewed by teachers attending a summer workshop at GSFC (see INTEGRAL E/PO, below). In addition, teachers attending this workshop will develop classroom activities, and test them with follow-on classroom testing. Selected activities will be included in the information booklet.

We have continued to support a variety of educator workshops and conferences (see attached list). These range from small, local workshops, to state and regional conferences, to national conferences. At the larger conferences we have both staffed NASA exhibit booths and presented workshops as part of the conference program. Many of the PowerPoint presentations for these workshops are now available on the Imagine web site.

2. I continue to oversee and provide guidance for the Lab's E/PO programs. In particular, I advise Ilana Harrus (USRA) on the XMM E/PO program. I have also continued to support the E/PO program for Swift by attending the Swift Education Committee meeting in Aug 2001, and providing feedback on the latest Swift materials covering Newton's Laws.
3. With Beth Jacob (SP Systems), I worked to have the 2nd Edition of the Lab's "Exploring the Extreme Universe" CD-ROM included in the SEUEF Education kits. Ten thousand of these kits will be distributed at the national and regional teacher meetings during 2002.

4. During this past year, I also oversaw the completion of the evaluation of the HEASARC web site and Browse tools by Cornerstone Evaluation Associates. I presented the results and recommendations to the HEASARC team. I also organized a "Usability Testing" workshop for the HEASARC by Cornerstone's Web reviewer.
5. I have continued to stay connected to the wider E/PO world through interactions with the Structure and Evolution of the Universe Education Forum (SEUEF), the Sun-Earth Connection Education Forum (SECEF) and the NASA Office of Space Science Education Ecosystem. I have participated fully in the SEUEF, contributing to their monthly telecons, assisting in planning the annual SEUEF education kits, and planning future projects. I have continued to attend OSS Education Council meetings, which provide information on latest trends in E/PO, and the directions and projects which OSS is undertaking. I continue to maintain good working relations with the OSS Broker/Facilitators, providing them our materials for their use in workshops and re-distribution.
6. Building on efforts begun last year, I have continued to strengthen our relationship with the American Association of Physics Teachers. We presented a half-day workshop based on our "Hidden Lives of Galaxies" materials at their winter meeting in Philadelphia. For that meeting, I also organized a NASA workshop with colleagues from SECEF and SEUEF to highlight content and classroom materials in these theme areas. During the meeting Jim Thieman (NASA/GSFC – SECEF) and I met with the director the AAPT Physics Teaching Resource Agents to discuss potential collaborations for presenting a joint SECEF-SEUEF workshop the PTRA session in summer 2003.
7. I collaborated with Christian Foster (UCSB) on the "Black Holes in a Different Light" workshop, which we presented at the NSTA National meeting in March 2002. We invited contributions for materials from others in the SEUEF, and received material from Lindsay Bartolone (MAP) and Shannon Range (Gravity Probe-B). We plan on doing the workshop together at the NSTA Regional meeting in Portland OR in Nov.
8. My collaborations with the GSFC Education Office continue to increase. With Sallie Smith, I completed our contribution to the Space Science Curriculum Matrix. I also worked with Ms. Smith to develop a classroom activity for the "Spinning Black Hole" lithograph, which is being prepared by GSFC PAO. Charles Mercer (Teacher on Loan) and Suzanne Pleau Kinneson (AESP) are working with us on the "Life Cycles of Matter" poster, and on the "Elements 2002" summer workshop. I planned a day of SEU theme science for the Vermont Space Science Institute, organized by Rosemary Millham (AESP) – unfortunately the Institute was canceled last summer, but we are planning to try again this summer.
9. On the invitation from Dr. Roy Gould (SAO-SECEF) I joined the SEU Roadmap Team in Jan. I'm working with Roy to write the E/PO sections of the Roadmap document, which lays out the SEU science and mission plan for the next 15 years. During the NSTA meeting in March 2002, I field-tested possible Roadmap themes and questions on teachers at the NASA exhibit booth.
10. Staying abreast of developments in space science is part-in-parcel to managing the "Features" on the Imagine Web site. I continue to work with Chris Wanjek (SP Systems) on news articles on latest discoveries. This past year, the Imagine site has featured discoveries and events from a number of satellites, including CGRO, Chandra, HESSI, TIGER, and XMM. Our latest video featured Dr. Tod Strohmayer's discovery of spinning black holes by RXTE. Working with the MAP mission, we complete a "Satellite Showcase" in preparation for the launch of MAP last summer.
11. I produced a 2-year E/PO plan for the Lab's involvement with the INTEGRAL mission. The HEASARC will serve as the data center for the US participation on this ESA gamma-ray observatory. Since one of its chief objectives is studying how the elements are created, I designed a program around the theme of the origin of the elements and gamma-ray astronomy. The former will be implemented via the next Imagine poster and information booklet (see above). To implement the latter, Jerry Bonnell (USRA) will produce a comic book on gamma-ray astronomy and instrumentation. Prototypes of these products will be previewed by teachers attending a summer workshop, "Elements 2002", which I am organizing. Teachers attending this workshop will also produce classroom activities appropriate for the material. These activities will be classroom tested in the Fall of 2002, and incorporated into the "Life Cycle of Matter" information booklet and Imagine site.

12. Implementation of the Astro E-2 E/PO plan began this year. Working with Ilana Harrus (USRA) and Koji Mukai (USRA), we finalized the schedule and the budget for the development. I recruited MAX Q Digital to produce the educational video. I worked with Ms. Charlotte Sappington (WVPT – Harrisonburg, VA) to plan a workshop with NTTI master teachers to be held summer 2002. These teachers will provide input for the video to maximize its educational value. In the future, NTTI teachers will write the teachers guide for the video.
13. This year I also brought to completion the development of the Cosmic Journeys Trading Card deck. I contracted with Nancy Leon (NASA/JPL) to create the deck, and worked with E/PO leads from Chandra, MAP, GLAST, and ACCESS to develop the deck. In the end, we produced full decks, sets of just the Mission Cards, and individual mission cards.

## **ACTIVITY 662-19: Advanced Satellite for Astrophysics and Cosmology (ASCA)**

### **DR. KEN EBISAWA:**

1. Since I moved to the INTEGRAL Science Data Center in Geneva in August 2001, I have been actively working on the INTEGRAL analysis software. In particular, I am responsible for the INTEGRAL Quick Look Analysis System, which is used to quickly detect new transient sources.
2. In cooperation with US and Japanese ASCA team members, I have completed the ASCA XRT and GIS calibration. The final calibration data will be released by summer 2002 together with the final ASCA SIS calibration data. I have found that the current ASCA attitude files do not take into account the leap seconds correctly, thus they have a slight time-shift (up to five seconds). When I visited ISAS in December 2001, I have corrected this problem in cooperation with Dr. Fujimoto. This fix will be incorporated in the final ASCA archives.
3. Participated in the ASTRO-E2 Science Working Group meeting in December 2001 at ISAS. When I visited ISAS in December 2001, I have carried out a precise arrival time correction on all the GINGA data, with which precise timing analysis (with the absolute accuracy ~1msec) is made possible. The ISAS GINGA archival system is being test-released to researchers in Japan. I am helping ISAS researchers to publicly release their GINGA archival system.
4. Using ASCA, XTE and Chandra satellite data, I have published several papers. I have participated in three international conferences, and one AAS meeting, and presented scientific results. My ADP proposals to use ASCA and GINGA data submitted in the previous year were accepted. I have submitted XTE and Chandra proposals.
5. I have submitted and then accepted a proposal to use the European Southern Observatory telescope in Chile to carry out an infra-red follow-up observation on the Galactic plane where we have observed in detail with Chandra. Observation will be carried out in July this year.

## **ACTIVITY 662-21: Super Nova Remnant Research**

### **DR. ZAVEN ARZOUMANIAN:**

1. Completed publication of a numerical study of the Galactic radio pulsar population (2002ApJ...568..289A, accepted 11/01/01)
2. Completed analysis of archival data on a central X-ray source in the DA 495 supernova remnant (publication in preparation)
3. Collaborated in the discovery of a dozen (and counting) new radio pulsars, including two young and one millisecond pulsars; follow-up observations are underway (publications in preparation, including June 2002 AAS poster.)
4. Carried out 15 observing runs on the Green Bank and Arecibo radio telescopes, ranging from a few hours to several days each. Most of this observing was done remotely (i.e., via the Internet), and provides useful information (pulsar ages, energy loss rates, distances) through long-term timing

4. Carried out 15 observing runs on the Green Bank and Arecibo radio telescopes, ranging from a few hours to several days each. Most of this observing was done remotely (i.e., via the Internet), and provides useful information (pulsar ages, energy loss rates, distances) through long-term timing
5. Oversaw one Chandra observation
6. Submitted 15 proposals, 7 as PI
7. Developed quality-control software for pulsar search data obtained at the Green Bank Telescope.

## **SUB-ACTIVITY 812-00: CHANDRA**

### **MS. LAURA BRENNEMAN:**

1. I have developed a series of scripts in IDL and PERL which apply CIAO, MARX and Ftools software to analyze Chandra data on NGC 3603 and XTE data on Eta Carinae with Dr. Corcoran. These programs concatenate various existing and original algorithms and greatly expedite the process of reducing and analyzing X-ray data. I have also created a script in PERL which facilitates the downloading and preparation of XMM data before its reduction. This script is now incorporated into the lab-wide array of programs.
2. I have reduced and analyzed Chandra HETG data on the binary systems Algol and UX Ari with Steve Drake.
3. I have aided both Mike Corcoran and Steve Drake in background research for forthcoming publications on NGC 3603 and UX Ari. This research includes literature searches, running simulations with MARX and Ftools software, and actual proposal preparation.
4. Along with Mike Corcoran, I have aided the XMEGA consortium and Dr. Tony Moffat in reviewing and editing "Galactic Starburst NGC 3603 from X-rays to Radio" for publication in ApJ (accepted, 2/02). Dr. Corcoran and I have also written the forthcoming companion piece to this article, "The X-ray Reconvolution of NGC 3603," which details the use of the MARX simulator in identifying and analyzing the X-ray sources in the core of the cluster.
5. I have prepared a poster for Steve Drake on our UX Ari spectral results for presentation at the "Cool Stars, Stellar Systems and the Sun" conference in Boulder, CO. This poster was entitled "The Quiescent Corona of UX Ari as seen by Chandra."
6. As a member of the Imagine the Universe! team, I edited two months of Astronomy Picture of the Day web pages for placement onto the annual APOD CD. Additionally, I am a volunteer on the Ask a High Energy Astronomer team. Duties consist primarily of answering questions from the public for a week every six weeks with a partner. Scott Owens and I average roughly 60 questions during our rotation. I am also currently a member of the Imagine! group working on a "Life Cycles of Matter in the Universe" educational poster and workbook geared toward high school science students.
7. I spent about a month this past fall assisting Craig Markwardt and Jean Swank in calibrating and testing new PCA background models for use with data from the XTE space observatory. My duties included implementation and testing of scripts Craig had designed with actual data using IDL, and then analyzing the results to determine the accuracy and robustness of the models.

## **ACTIVITY 5094: Astrophysics Data Program**

### **DR. KIRPAL NANDRA:**

1. 9 publications in refereed journals and 2 conference papers. 3 journal papers submitted. Several projects in progress
2. Several talks at conferences and colloquia.
3. XMM AO-2, 2 proposals submitted as PI, several others as co-I. Chandra AO-4, 1 proposal submitted as PI, several as co-I. Hubble Space Telescope Cycle 11: 1 proposal submitted as PI and two as co-I.

4. Minor maintenance work on TARTARUS database. Detailed plan for science exploitation formulated.
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## **LABORATORY FOR ASTRONOMY AND SOLAR PHYSICS (680)**

### **ACTIVITY 682-01: Solar and Heliospheric Observatory (SOHO)**

#### **DR. FREDERIC AUCHERE:**

1. Showed that as it is the case for hydrogen, helium produces a strong emission line in the solar corona. Detection of the line provides new powerful diagnostic tools for probing the solar wind. The HERSCHEL mission was designed on the basis of the discovery.
  2. Showed the possibility to compute solar spectral irradiances at any point in the heliosphere using SOHO data. This result has major implications in planetary atmosphere sciences, interplanetary and interstellar media sciences, etc.
  3. Development, calibration and launch of the EIT/CalRoc instrument. Participated in the design of the HERSCHEL rocket-borne suite of instruments. Participated in the design of the AIA suite of instruments for the SDO mission. Consulting activity for the SECCHI/STEREO mission.
  4. Absolute radiometric calibration of the EIT/SOHO instrument. This result greatly enhances the scientific output of the whole SOHO mission.
  5. Maintenance of the EIT software and EIT users guide ([http://umbra.nascom.nasa.gov/eit/eit\\_guide/guide.html](http://umbra.nascom.nasa.gov/eit/eit_guide/guide.html)) that describes the procedure to analyze EIT data.
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## **LABORATORY FOR EXTRATERRESTRIAL PHYSICS (690)**

### **ACTIVITY 690-05: Electrodynamics Forecast Modeling**

#### **DR. DIMITRIS VASSILIADIS:**

1. Modeling of energetic electron environment.
  - a) Paper on seasonal/solar cycle variations of electron flux accepted in JGR in December 2001.
  - b) A second paper, on the nonlinearity of the electron response according to region and time, has been okayed by co-authors, and will be submitted in May. In addition we have mapped the radial and MLT structure of the electron radiation belt's outer zone using data from two spacecraft in the last two solar cycles. We have found that the response to the solar wind input is strongly differentiated by radial position. Recently we found that the spatial two-point correlation can be used to segment the radiation belt in 4 radial-distance zones: L=1-2, L=2-3, L=3-4, L=4-7, L=7-15. While solar wind velocity is the most geoeffective driver for electron flux in the region L=4-7, other regions respond to different drivers.
2. Modeling and prediction of high-latitude electrodynamic system...i. Identifying major current systems, incl. dynamics in response to the solar wind.
  - a) Work with GSFC scientist A.J. Klimas and NRC postdoc R.S.Weigel.
  - b) Continue collaboration with A.J. Ridley of Univ. of Michigan.
  - c) Results presented in conferences.

3. Work with A.J.Klimas and NRC postdoc V.M. Uritsky.
4. Special duty: Organized special session in AGU. The session was successfully and selected papers have been submitted for publication in a section of the AIP journal Physics of Plasmas.
5. Robert Weigel has presented his work on high-latitude geomagnetic disturbances, in particular fluctuations and their correlation in the last two AGU meetings. A related paper was accepted by GRL in February, and he is preparing a longer paper for JGR.
6. Several papers, 2 NSF proposals, and 6 NASA (GIP) proposals were reviewed.

## **ACTIVITY 690-11: Space Plasma Physics**

### **DR. SEAN CHEN:**

1. Discovery of ionospheric plasma population near the magnetopause at low latitudes and solar wind and interplanetary magnetic field dependence of thermal ions near the Earth's polar cusps.
2. Analysis of TIDE instrument sensitivity decay in time related to solar EUV flux and geomagnetic activities.

### **DR. YIHUA ZHENG:**

1. Preliminary results show the energization of plasmas and increase of fluxes level after the model taking wave-particle interactions into consideration, which is very encouraging. Energetic ion fluxes and the associated energetic neutral atom (ENA) emissions were able to be simulated using different field models.
2. The simulation results of several magnetic storms have been used by other scientists to do comparison studies with the IMAGE measurements, and to deepen our understanding of magnetospheric phenomena. The simulation results will form the basis of a review paper on Ring Current ion and ENA simulation currently being written by Fok.
3. Expedite the final delivery of Fok and coworkers' radiation forecasting model to Air Force for space weather forecasting purpose. The website of <http://johanna.gsfc.nasa.gov> has been proven very useful in sharing our simulation results with other scientists.
4. Submitted a paper to Journal of Geophysical Research.

## **ACTIVITY 695-01: Magnetospheric Physics**

### **DR. NIKOLAI TSYGANENKO:**

A new data-based model has been developed of the inner and near magnetosphere, representing the variable configuration of the geomagnetic field for different interplanetary conditions and ground disturbance levels. The input parameters of the model include the Dst-index (SYM) and the solar wind parameters (bulk speed, proton density, and IMF components), at the time of observation and also during the preceding 1-hour inter-val. The model output is the predicted magnetospheric B-field vector (in GSM coordinates). The model is based on a new set of data, mostly taken in 1994-1999 by the ISTP spacecraft Polar and Geotail, and complemented by observations from the earlier missions ISEE-2, AMPTE/CCE/IRM, CRRES, and DE-1. The interplanetary medium data for this effort came from solar wind and IMF monitors onboard Wind and IMP 8 spacecraft. The model magnetospheric boundary was specified using a most recent empirical approximation by Shue et al. Its size is controlled by the solar wind pressure, and its shape also varies in response to the tilt of the Earth's dipole. The model magnetopause confines the total field inside the boundary, but it also allows an IMF-controlled interconnection due to a finite normal component, resulting in open magnetospheric configurations. The degree of predicted IMF penetration inside the magnetosphere, derived from data, was found to greatly increase as the IMF turned southward. The IMF orientation and magnitude was also confirmed as the

major factor, controlling the magnitude and spatial extent of the model Birkeland currents: both Region 1 and 2 currents strongly increase and shift equatorward at low altitudes during south-ward IMF periods. The model replicates the dramatic buildup of the dawn-dusk asymmetry of the inner magnetosphere during storms, associated with the development of the partial ring current, a feature absent in earlier data-based models. Fitting the model to the data revealed a striking predominance of the partial ring current over the axisymmetric ring current during major disturbances, in good agreement with recent particle simulations by the Michigan University group.

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**COOPERATIVE PROGRAM IN SPACE  
SCIENCE  
(CPSS)**

**NASA COOPERATIVE AGREEMENT  
NCC 5 – 356 & NCC 5 - 637**

**Publications Listing  
1 October 2001 through 30 September 2002**

**UNIVERSITIES SPACE RESEARCH ASSOCIATION  
(USRA)**

**David V. Holdridge  
Program Manager**

## **USRA CPSS 2001 - 2002 Scientific Publications List (partial)**

1. Akylas, A.; Georgantopoulos, I.; Griffiths, R. G.; Papadakis, I.; Mastichiadis, A.; **Nandra, K.**; Warwick, R. S.; Smith, D. A.; 2002: "Monitoring RXTE observations of Markarian 348: the origin of the column density variations;" MNRAS, in press.
2. Albacete Colombo, J. F.; Morrell, N. I.; Niemela, V. S.; **Corcoran, M. F.**; 2001: "Optical Spectroscopy of X-Mega Targets - I. CPD -59 2635: A New Double-Lined O-Type Binary in the Carina Nebula;" Monthly Notices of the Royal Astronomical Society, Volume 326, Issue 1, pp. 78-84.
3. **Arzoumanian, Z.**; Chernoff, D. F.; & Cordes, J. M., (both of Cornell University); 2002: "The Velocity Distribution of Isolated Radio Pulsars;" ApJ., 568, 289A.
4. Asaoka, Y.; et al. (including **Moiseev, A.**); 2002: "Measurement of Cosmic-Ray Low-Energy Antiproton and Proton Spectra in a Transient Period of Solar Field Reversal;" Physical Review Letters, 88, 5.
5. **Auchère, F.**; Hassler, D. M.; Slater, D. C.; & Woods, T. N.; 2001: "SwRI/LASP Sounding Rocket Inter-Calibration with the EIT Instrument on Board SOHO;" Solar Physics, 202(2), 269.
6. Balucinska-Church, M.; Barnard, R.; Church, M. J.; & **Smale, A. P.**; 2001: "Neutron Star Blackbody Contraction During Flaring in X1624-490;" A&A, 378, 847.
7. Barnard, R.; Balucinska-Church, M.; **Smale, A. P.**; & Church, M. J.; 2001: "A Study of the Spectral Evolution During Dipping in XB1323-619 with Rossi-XTE and BeppoSAX," A&A, 380, 494.
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10. Boyd, P. T.; **Smale, A. P.**; & Dolan, J. F.; 2001: "X-ray and UV Orbital Phase Dependence in LMC X-3;" ApJ, 555, 822.
11. Camilo, F. (Columbia); Stairs, I. H. (NRAO Green Bank); Lorimer, D. R. (Jodrell Bank); Backer, D. C. (Berkeley); Ransom, S. M. (McGill, MIT); Klein, B. (MPIfR); Wielebinski, R. (MPIfR); Kramer, M. (Jodrell Bank); McLaughlin, M. A. (Jodrell Bank); **Arzoumanian, Z.** (USRA); Muller, P. (MPIfR); 2002: "Discovery of Radio Pulsations from the X-Ray Pulsar J0205+6449 in Supernova Remnant 3C58 with the Green Bank Telescope;" ApJ, in press (astro-ph/0204219).

12. Chaty, S.; Haswell, C.; Hynes, R.; **Shrader, C.**; & Cui, W.; 2002: "Multiwavelength Observations Revealing the Outbursts of the Soft X-Ray Transients XTE J1859+226 and XTE J1118+480;" MNRAS (accepted).
13. **Corbet, R. H. D.**; & Peele, A. G.; 2001: "4U2206+54- An Unusual High-Mass X-Ray Binary with a 9.6 Day Orbital Period but no Strong Pulsations;" Astrophysical Journal, 562, 936.
14. **Corcoran, M. F.**; Ishibashi, K.; Swank, J. H.; Petre, R.; 2001: "The X-Ray Light Curve of Eta Carinae: Refinement of the Orbit and Evidence for Phase-Dependent Mass Loss;" The Astrophysical Journal, Volume 547, Issue 2, pp. 1034-1039.
15. **Corcoran, M. F.**; Swank, J. H.; Petre, R.; Ishibashi, K.; Davidson, K.; Townsley, L.; Smith, R.; White, S.; Viotti, R.; Daminieli, A.; 2002: "The Chandra HETGS X-Ray Grating Spectrum of Eta Carinae;" The Astrophysical Journal, Volume 562, Issue 2, pp. 1031-1037.
16. **Corcoran, Michael F.**, USRA & NASA/Goddard Space Flight Center; review article on X-ray Astronomy: Encyclopedia of Physical Sciences and Technology, Third Edition, Volume 17, 2002, Academic Press
17. Cravens, T. E., (UI); Robertson, I. P., (UI); and **Snowden, S. L.**; 2001: "Temporal Variations of Heliospheric X-ray Emission Associated with the Solar Wind;" in the Journal of Geophysical Research, **106**, 24883-24892.
18. De Martino, D.<sup>1</sup>; Matt, G.<sup>2</sup>; **Mukai, K.**<sup>3,4</sup>; Belloni, T.<sup>5</sup>; Bonnet-Bidaud, J. M.<sup>6</sup>; Chiappetti, L.<sup>7</sup>; Gaensicke, B. T.<sup>8</sup>; Haberl, F.<sup>9</sup>; Mouchet, M.<sup>10,11</sup>; 2001: "The X-ray Emission of the Intermediate Polar V709 Cas;" A&A 377, 499.  
<sup>(1)</sup>Osservatorio Astronomico di Capodimonte; <sup>(2)</sup>Universita ROMA III;  
<sup>(3)</sup>NASA/GSFC; <sup>(4)</sup>USRA; <sup>(5)</sup>Osservatorio Astronomico di Merate; <sup>(6)</sup>Service d'Astrophysique Saclay; <sup>(7)</sup>Istituto di Fisica Cosmica; <sup>(8)</sup>Universitaets Sternwarte Goettingen; <sup>(9)</sup>MPI fur Extraterresrische Physik; <sup>(10)</sup>DAEC Observatorie de Paris; <sup>(11)</sup>Universite Denis Diderot.
19. **Deines-Jones, P.**; Black, J. K.; Crawford, H.; Hunter, S. D.; 2002: "Imaging Micro-Well Proportional Counters Fabricated with Masked UV Laser Ablation;" Nucl. Instr. Meth. A 477, 55-58.
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22. do Couto e Silva, E.; Anthony, P.; Arnold, R.; Arrighi, H.; Bloom, E.; Baughman, B.; Bogard, J.; Bosted, P.; Bumala, B.; Chektman, A.; Cotton, N.; Crider, A.; Dobbs-Dixon, I.; Djannati-Atai, A.; Dubois, R.; Engovatov, D.; Espigat, P.; Evans, J.; Fieguth, T.; Flath, D.; Frigaard, M.; Giebels, B.; Gillespie, S.; Godfrey, G.; Grove, J.; Handa, T.; Hansi, T.; Hernando, J.; Hicks, M.; Hirayama, M.;

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  25. **Ebisawa, K.**; **Mukai, K.**; Kotani, T.; Asai, K.; Dotani, T.; Nagase, F.; Hartmann, H. W.; Heise, J.; Kahabka, P.; van Teeseling, A.; 2001: "X-ray Energy Spectra of the Super-soft X-ray Sources CAL 87 and RX J0925.7-4758 Observed with ASCA," ApJ, 550, 1007-1022.
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  31. **Harris<sup>1</sup>, M. J.**; Teegarden<sup>3</sup>, B. J.; **Weidenspointner<sup>1</sup>, G.**; Palmer<sup>1,2</sup>, D. M.; Cline<sup>3</sup>, T. L.; Gehrels<sup>3</sup>, N.; and Ramaty<sup>3</sup>, R.; 2001: "TGRS Observations of Gamma-Ray Lines from Novae. III. The 478 keV Line from <sup>7</sup>Be Decay;" Astrophysical Journal, **563**, 950-957. <sup>1</sup> Universities Space Research Association; <sup>2</sup> NIS-2, D346, Los Alamos National Laboratory, Los Alamos, NM 87544; <sup>3</sup> NASA Goddard Space Flight Center, Code 661, Greenbelt, MD 20771
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